Fun Physics: Color & Light (Grades 3-5)

AKA Science

WELCOME TO AKA SCIENCE!

AKA Science is a fun, hands-on afterschool science enrichment program for grades K-8. With inquiry-based, interactive activities, students are encouraged to work together, ask questions, and dive deep into the wonders of science. From biology, chemistry, and physics to engineering, earth science, and environmental science, we playfully discover the world around us and make connections that last a lifetime. ALL KIDS ARE SCIENTISTS and together we help them see themselves as the next generation of innovators, inventors, and experimenters!

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BEFORE YOU START:

- **NOTHING from the AKA Science kit should go in one's mouth, nose, eyes, or ears.** Mystery substances can be harmful, and even familiar substances can be contaminated. If a student ingests a non-food product, call **Poison Control: 1-800-222-1222**, 911, or alert your manager.
- **Ensure that the *Take-Home Supply Advisory* goes home** into the hands of your students' parents, guardians, and caring adults so that they can anticipate what exciting and potentially messy supplies may be coming home.
- **The AKA Science website (www.akascience.org)** has copies of worksheets, curriculum, teaching resources, and parent/guardian forms. Below are QR codes for specific parent/guardian forms in other languages:

Arabic Chinese English Russian Spanish Vietnamese

- **Utilize the newspaper included in your kit box.** It is helpful for covering desks or laying flat on the floor to catch any spills.
- **Encourage students to use their Lab Notebooks** to plan, record, and reflect on observations.
- **You may not have time to do every activity in the curriculum with your class**—and that's okay! It's up to you which activities to shorten, lengthen, or skip if needed.
- **Throughout the curriculum, all materials will be in BOLD when it's time to pass them out and all vocabulary words will be UNDERLINED.**
- **A BLACK STAR at the beginning of an activity means the lesson is associated with a post-survey question.** We encourage you to emphasize the specific word/phrase during the lesson.
- **In science, making mistakes is part of the process!** If a student is feeling discouraged because an experiment didn't work, we invite you to try the following:
    1. *What happened today that made you try hard? What did you learn from this?*
    2. *What other strategies or improvements could you try next time?*

CLASS 1: SURPRISING EYES

Supplies (in class bags)	**#**
Butcher Paper (sheet, folded) *in bottom of kit box*	1
Crayons, black	4
Crayons, box	2
Cups, 10oz	4
Lab Notebooks	16
LED light, blue	4
LED light, green	4
LED light, red	4
LED light, white	4
Lenses, concave	4
Lenses, convex	4
Markers, black, washable	2
Mirror boards	4
Pencils	16
Ping pong balls	20
Pipe cleaners, ½ size	16
Pushpins	4
Tape, Scotch rolls	1
Worksheets (in envelope)	**#**
Blind Spot strips	16
Consent Form for Publication (Media Release)	16
How Lenses Bend Light	2
Supply Advisories	16

PREP STEPS:

- **Act 3. (optional):** Poke two holes across from each other in 16 ping pong balls. Note – there are extra ping pong balls in case any are damaged.
- **Act 5.** Fill four 10oz cups about ¾ full of water.

VOCABULARY:

- **Concave:** Having an outline or surface that curves inward like the interior of a circle or sphere.
- **Convex:** Having an outline or surface that curves outward like the exterior of a circle or sphere.
- **Hypothesis:** A prediction of the outcome of a test. A hypothesis must be testable through experimentation or observation.

- **Optic Nerve**: Large cranial nerve that connects the eye to the brain. The optic nerve is responsible for transmitting information from the retina to the vision center of the brain via electrical impulses.
- **Peripheral vision:** What is seen on the side, above, or below by the eye when looking forward, without moving your head.
- **Pupil:** Opening in the eye that allows light to enter. Pupils change size depending on how much light is available.
- **Retina:** A layer of tissue at the back of the eyeball containing cells that are sensitive to light and that trigger nerve impulses that pass via the optic nerve to the brain, where a visual image is formed.

ACTIVITY 1: SET THE TONE

TIME: 15 Minutes

Supplies	#
Butcher Paper (sheet, folded)	1
Marker, black washable	1

GOAL: Establish your class community by doing a group check-in, learning names, and creating class agreements.

PROCEDURES:

NOTE: Start calling students "scientists" throughout the program. This encourages them to see themselves as the scientists they naturally are!

a) Thumb Check (OPTIONAL at the beginning of each class)(1 minute):

1. Gather students in a circle.
2. Do a quick "thumb check" to see how everyone is doing (e.g., students silently show how they're doing by using their thumb as a gauge/meter. Thumb up is rating something highly, thumb down is rating something lowly, and feelings in between are rated as a thumb pointed towards the middle.)
3. First, ask students how they are feeling physically (e.g. thumb up = energized/ready to run a marathon and thumb down = sick/tired/injured.)
4. Next, ask students how they are feeling emotionally (e.g. thumb up = happy/glad/proud/interested and thumb down = sad/mad/bored.)
5. Thank students for sharing!

b) Name Game (4 minutes):

1. Gather students in a circle and facilitate a name game.
2. Have students stand in a circle and find a small object safe to toss between players.
3. The first player will state their name followed by the name of another player. BEFORE tossing the object the first player will make eye contact with whom they are tossing the object to, then toss the object.
4. Each player then repeats the process of stating their name, the name of a player who hasn't played yet, then making eye contact and tossing the object (*note: if it's difficult to keep track of which players have had a turn, create an identifier such as pointing a foot into the circle once they've had a turn)
5. Once all players have had a turn, students can have the option to either repeat the same order at a faster pace or reverse the order that they previously did.
6. Alternatively, if the above name game isn't your cup of tea, you can try this one: Students say two words and do a movement (optional) - their name and a word that sounds like how their name starts (e.g. "Jumpy Justin") and Justin would make a jumping motion. The group would repeat it back (along with the movement.) Then the next person would say their name (e.g. "Dab David") and do a dab movement that the group would repeat back. And so on. Note that the movement just has to start with how the person's name sounds (e.g. "Silly Celia" works even though Silly starts with "s" and not "c.")

c) Class Agreements (10 minutes):

1. Once the Name Game is completed, retrieve your **butcher paper and marker** and facilitate a student discussion to establish class agreements. Class agreements are useful "rules" on how we will all work together in the classroom space and ensure everyone feels heard and respected.

   Example questions:

   - *We have limited supplies in class. How can we share?*
   - *How do we safely use science supplies?*
   - *What is appropriate/inappropriate behavior in class?*
   - *How do we want to be treated in class?*
   - *How can we be our best selves in class?*
   - *What happens if someone breaks one of our agreements?*
   - *What are the clean-up procedures?*

6. Once agreements are established, have students sign their name directly onto the paper, or use a stamp pad and thumb print.

ACTIVITY 2: PAIR & SHARE

TIME: 10 Minutes

Supplies	**#**
Pencils	16
Lab Notebooks	16
Worksheets	**#**
Consent Form for Publicity	16
Supply Advisories	16

GOAL: Gauge students' knowledge of today's subject and invite questions.

PROCEDURE:

1. Pass out **a notebook and a pencil** to each scientist.
2. Ask a question that relates to today's subject. Have the scientists answer the question by drawing or writing in their notebooks or simply thinking about it.

   Example Questions:
   - *What is science?*
   - *What is physics?*
   - *How is color and/or light related to science?*
   - *Can you name the parts of our eyes?*

3. Ask the scientists to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.
4. If they ask you questions and you don't know the answer, that's OK! Tell your scientists that you can find out together, either by looking up the answer or trying the class experiments. Showing children that adults don't always have the answer shows them that we are always learning, even when we are grown up.
5. Be sure to pass out the **Consent Form for Publicity and the Supply Advisory** to all students either now or at the end of class. It is important to send these forms home on the first day.

ACTIVITY 3: MODEL EYE

TIME: 15 Minutes

SOURCE: bit.ly/451XwGT

Supplies	#
Crayons (black)	4
Crayons (box)	1
LED Lights (blue)	4
LED Lights (green)	4
LED Lights (red)	4
LED Lights (white)	4
Ping Pong Balls	16
Pipe Cleaners (half size)	16
Pushpins	4

BACKGROUND:

Our eyes are complex organs that allow us to see the world. Light enters through the pupil and is projected on the back of your eye. The image is translated into a signal that travels down the optic nerve attached to the back of each eye. The optic nerve sends the images from the eye to your brain. Scientists are trying to build prosthetic eyes! Prosthetics are eye replacements that can wire to the brain and help blind people regain their vision. They're getting better, but because your vision is so complex, engineers are still learning about how to connect a prosthetic eye to the brain through the optic nerve. If only it was as simple as using a pipe cleaner! (bit.ly/3OjwwLO)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. Select the hypothesis (Circle one)**:**

A. Mirrors reflect objects and bounce light rays.

GOAL: To create a simple model of the eye so scientists can visualize how our bodies process images.

WHAT GOES HOME: Finished model eye.

PROCEDURE:

1. **Tell scientists:** Dr. Patricia Bath was a famous eye doctor (ophthalmologist) and scientist. As the first black woman ophthalmologist in America, she invented a way to use lasers to cure some types of blindness! Today we are going to study how our eyes work, just like Dr. Bath.
2. Put scientists into four groups. Give each group **a pushpin, a black crayon, and a few colored crayons**.
3. Give each scientist **a ping pong ball and a half piece of pipe cleaner**.
4. Have students use a black crayon to draw a pea-sized circle in the center of the ball (this is the pupil). If the holes were prepared beforehand, have students draw the black circle around one of the holes. Color the circle to make it solid black.
5. If the holes weren't prepared, have students take turns using pushpins to carefully poke a hole through the black circle on the ping pong ball. After the hole is poked, wiggle the pin around to widen the hole to the size of a pencil tip (Photo 1.1).
6. Have students draw a larger circle with any color they choose (this is their iris) around the smaller pea-sized black circle.
7. Have students stick one end of the pipe cleaner into the back of the ping pong ball. If needed, they can use the pushpin to create the hole, then thread the pipe cleaner through it. The pipe cleaner represents the optic nerve**.** Have students guess which pieces represent which parts of the eye before you reveal the answers (Photo 1.2).
8. Hand each student **one LED light**. Try to make sure the students in each group have different colors of LED lights.
9. Go over LED light safety with students. Shining LED lights directly into an eye can cause damage and temporary blindness. Students should only turn their lights on when instructed to do so and should turn them off immediately after they use them for a task. Lights should always be pointed at the ground unless students are instructed otherwise.

   Discussion Prompts:

   - *What part of the eye do you think the white part represents?*
   - *The pipe cleaner?*
   - *The small pea-sized dot?*
   - *The larger circle around it?*

10. Turn off the lights.
11. Have students point their LED lights at the ground then switch them on. If a light is dim or out, try squeezing, shaking, or tapping the light. Usually, the wiring just isn't perfectly lined up, and those actions will realign it.
12. Explain to your scientists that a hypothesis is a testable question used in science. Tell them that as scientists, they will be making hypotheses throughout the AKA Science program. Hypotheses are sometimes in the form of an If-then statement, such as "If (I do this), then this

(will happen).” They can also sound more like a statement. Either way, they must contain wording about something you can test!

   a. “I think a mirror is useful” is an opinion.
   b. “Can a mirror reflect objects?” is a question.
   c. “If I shine a light in a mirror, then the light rays will bounce off it” is a hypothesis.
   d. “Mirrors reflect objects and bounce light rays” is a hypothesis statement.

13. Ask students to make a <u>hypothesis</u> about where the light will shine when we point it into their model eye.
14. Have students hold their model eye in one hand with the pupil pointed towards the light. Being careful not to shine their lights in anyone’s eyes, have them shine the light through the pupil hole into the model eye. The light will cause a bright spot to appear inside the ping pong ball (this is the <u>retina</u>, which receives the light after it passes through the pupil and lens then sends signals along the optic nerve to the brain) (Photo 1.3).

TIP: Practice making hypotheses with your class every time you see the word “<u>hypothesis</u>” or “<u>hypothesize</u>” in the curriculum!

<u>ACTIVITY PHOTOS:</u>

1.1 

1.2 

1.3 

ACTIVITY 4: BLIND SPOT

<u>TIME:</u> 5 Minutes

<u>SOURCE:</u> *Biology Life on Earth - 7th ed. by Teresa & Gerald Audesirk & Bruce Byers*

Supplies	**#**
Pencils	16
Worksheets	**#**
Blind Spot (strips)	16

BACKGROUND:

As you learned from the eye model, the retina receives light and turns it into signals. However, at the spot where the optic nerve exits the eyeball—where your pipe cleaner is connected to your ping pong ball—the retina can't receive light, which creates a small blind spot in our field of vision. Usually, the brain fills in the gap with information from our environment and our other eye, so we're not aware that anything is missing. Some animals don't have blind spots! An octopus doesn't have a blind spot because the nerves in its eyes don't block any cells, so its whole eye is able to see. (bit.ly/3rKhwyK)

GOAL: Explore our natural blind-spots using a vision exercise

WHAT GOES HOME: Blind spot strip

PROCEDURE:

1. Give each scientist a **Blind Spot strip and a pencil**. Have them hold the strip so that the star is on the left and the dot is on the right.
2. Have students cover their left eye and hold the strip about an inch from their face, with the star on the left (Photo 1.4). They should:
   a. Focus on looking at the star and notice the dot visible in their peripheral vision. *Make sure the star is on the same side as the covered eye, i.e., both on the left.*
   b. *Slowly* move the paper away from their face, staring at the star, and watching for the moment the dot disappears and then reappears in their peripheral vision.
   c. If any students don't see the dot disappear and reappear, they can try covering their right eye instead of their left.

Discussion Prompts:

- *What happened?*
- *Why did the dot disappear?*
- *Where else do we talk about blind spots?*

3. If time allows, have students draw a straight line between the star and the dot with a pencil, then repeat the activity. When the dot disappears, it looks like the line goes straight through the empty space!

TIP: If your scientists are having trouble with this activity, try taping the strip to the wall and have them move their bodies back and forth (Photo 1.5).

ACTIVITY PHOTOS:

1.4


1.5


ACTIVITY 5: LENS-A-PALOOZA

TIME: 15 Minutes

SOURCE: Sarah Andersen, Oregon Health Career Center

Supplies	#
Cups (10oz, plastic, tall)	4
LED Lights (blue)	4
LED Lights (green)	4
LED Lights (red)	4
LED Lights (white)	4
Lenses (concave)	4
Lenses (convex)	4
Mirror Boards	4
Water	
Worksheets	**#**
How Lenses Bend Light	2

BACKGROUND:

Light travels in a straight line, until it encounters something like water, glass, or plastic. These substances slow the ray of light and "bend" it before it continues along its path. This is how lenses work, whether they are the lenses of our eye or made of plastic and used for glasses. Light traveling through the air enters the lens, and depending on the type of lens, the light is bent in a certain direction. In convex lenses, light is bent together so it converges to a point in front of your eyes. In concave lenses, the light is bent so that when it leaves the lens, it scatters away in different directions.

Devices like microscopes and telescopes use compound lenses, which combine multiple lenses to highly magnify the object being viewed (bit.ly/3s0ET7t).

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. What happens to light when it passes through things like water or binoculars?

A. The light bends

GOAL: To examine how lenses and water can change the path of light.

WHAT GOES HOME: Nothing

PROCEDURE:

1. Group students into four groups. Provide each group with **one of each type of lens (convex and concave), 4 LED lights (one of each color), a cup for water (from prep), and a mirror board**. Warn students that the glass lenses are delicate, so they should try not to drop them. Further, the lenses will work best if they avoid getting their fingerprints on the glass. Demonstrate holding the lens by its sides.
2. Have the students start by examining and comparing their two lenses, and then discuss what they notice.
3. Discuss the difference between concave and convex lenses (concave lenses bend inward, convex bulge outward).

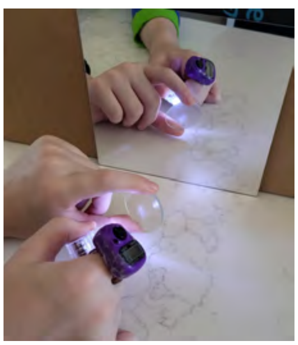
Discussion Prompts:

- *Can you think of any everyday objects that use lenses?*
- *How are the two lenses in front of you different and similar? Do you think they bend light in the same way?*

4. Have the students hypothesize what will happen with each lens when a light is shined through it. Will the color of the LED make an impact?
5. Show students the **How Lenses Bend Light worksheet**. Place the two copies around the room so that each student can see one of them.
6. Have the groups hold their lenses so they are positioned in front of the mirror board. The mirror board can be either propped against a wall or held by one scientist in each group.
7. Have the students experiment with shining their LED lights through each lens. It may be helpful to dim the lights in the room for this (Photo 1.6).
8. Challenge the students to try to use one of the lenses to focus the flashlight beam into a single point on the wall. Have them compare their attempts with each of the lenses.

9. Encourage the students to experiment with the distance between the flashlight and their lenses as well as the distance between their lenses and the wall.
10. Have the students line up both lenses at once in front of the flashlight beam and see what happens. Try this in both configurations (i.e., convex in front concave, and concave in front of convex).
11. Now have the scientists switch to shining the light through the cup of water onto the mirror board. Which made a bigger impact on focusing the beam of light – the cup of water or one of the lenses (Photo 1.7)?
12. What happens if they use a lens and the water (Photo 1.8)? Does the ray of light change? Does the color of the LED matter (Photo 1.9)?
13. Have the students pass the lenses around in their group and look through them. Encourage the students to notice if objects look larger, smaller or the same size.

ACTIVITY PHOTOS:

1.6 
1.7 
1.8 
1.9 

ACTIVITY 6: DAILY DEBRIEF

TIME: 5 Minutes

GOAL: Reflect on what was explored during the activities and relate to students' own lives.

PROCEDURE:

1. Gather students in a circle.
2. Ask questions that facilitate a thoughtful reflection of the day's lessons. Questions may be considered in a Pair & Share model.
3. If you are short on time, have students think about the questions while they are cleaning up from the activities.

Example questions:

- *What happened today?*

- *What would it be like to have a third eye?*
- *What was a challenge that you overcame?*
- *What would we do if we had more time?*
- *How does what we learned today apply to your personal life?*

CLEAN UP: Implement a fun, daily clean-up routine so that students practice being "truly helpful" to their AKA Science community.

WHAT TO SAVE: Some items will carry over into future classes and others will require proper disposal. We have created a table to help organize your materials by when they will be used again. If an item has a number in the column marked "move to:", all the items used today should be moved to the new class bag. If marked "send home", the items are to go home with your scientists. "Save for SUN, recycle, or discard" means the items can be kept for use by your site or discarded as needed.

******Remember to send home the Supply Advisory and Consent Form for Publicity with each person today. If the Consent Form for Publicity is returned, you can take pictures of students doing activities!******

Fun Physics: Color & Light (Grades 3-5)

Class 1: Surprising Eyes

Supplies	Move to:	Send home	Save for SUN, recycle, or discard
Butcher Paper (sheet, folded)	Kit box		
Crayons, black	Class 2		
Crayons, box	Class 2		
Cups, 10oz	Class 4		
Lab Notebooks	Class 2		
LED light, blue	Class 4		
LED light, green	Class 6		
LED light, red	Class 4		
LED light, white	Class 4		
Lenses, concave			X
Lenses, convex	Class 2		
Markers, black, washable	Class 4		
Mirror boards	Class 5		
Pencils	Class 2		
Ping pong balls		X	
Pipe cleaners, ½ size		X	
Pushpins	Class 3		
Tape, Scotch rolls	Class 3		
Worksheets			
Blind Spot strips		X	
Consent Form for Publication (Media Release)		X	
How Lenses Bend Light	Envelope		
Supply Advisories		X	

GRAND TOTAL OF WHAT GOES HOME: Model eye, blind spot strip, supply advisory, consent form for publication

CLASS 2: EYE ON THE PRIZE

Supplies (in class bags)	**#**
3D glasses	16
Crayons, black	4
Crayons, blue	4
Crayons, box	4
Crayons, red	4
Cups, 9oz punch	4
Cups, dixie	8
Eye patches	16
Lab notebooks	16
Lenses, convex	4
Mirrors, 2x3in	16
Newspaper, bundle - *in bottom of kit box*	1
Paper towels, roll - *in bottom of kit box*	1
Pencils	16
Pennies	16
Pipettes	4
Pitcher - *in bottom of kit box*	1
Scissors (site provides)	16
Water	
Worksheets (in envelopes)	**#**
3D Images (double-sided half sheet)	16
How Lenses Bend Light	2
Paper, white, full sheet	16
Secret Decoder Message (quarter sheets)	16

PREP STEPS:

- **Act 3a:** If present, peel plastic film from the front of all 2x3 inch mirrors.
- **Act 3b:** Fill the four 9oz punch cups half full of water.
- **Note:** Throughout the class, newspaper is used as needed to protect surfaces and paper towels are for cleaning up liquids.

VOCABULARY:

- **Cornea:** The transparent layer forming the front of the eye.
- **Iris:** The colored part of the eye surrounding the pupil. Muscles in the iris expand or contract to change the size of the pupil, depending on how much light is available.

- **Lens:** A transparent lens-shaped or nearly spherical body in the eye that focuses light rays upon the retina.
- **Observations:** A record or description of an event, object, or idea.
- **Pipette:** Thin dropper that is used to measure and transfer liquids.
- **Sclera:** The white outer coating of the eye.

ACTIVITY 1: LAND ACKNOWLEDGEMENT

TIME: 5 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16

GOAL: A Land Acknowledgement acknowledges not only the ancestral lands, but also the historical and complex intersections of settler impacts on Indigenous histories, economies, ecologies, livelihood, well-being and governance structures. Land Acknowledgements are an expression of gratitude and appreciation to those whose territory you reside on, and a way of honoring the Indigenous people who have been living and working on the land from time immemorial. We share the Land Acknowledgement with our students to create space for reflection and to inspire support for Indigenous communities.

PROCEDURE:

1. Pass out **notebooks and pencils** to your scientists.
2. Ask the scientists if they know what a Land Acknowledgement is.
3. Read the following Land Acknowledgement aloud to your class:

   We recognize the unique and enduring relationship that exists between Indigenous People and their traditional territories. We acknowledge that we are on the historic homeland of the Multnomah, Wasco, Cowlitz, Kathlamet, Clackamas, Bands of Chinook, Tualatin, Kalapuya, Molalla tribes. Let this acknowledgement serve as a reminder of our ongoing efforts to recognize, honor, reconcile and partner with the Indigenous peoples whose lands and water we benefit from today.

> **TIP:** If you would like a different Land Acknowledgement to read to your class, please check **akascience.org** for more resources.

Discussion Prompts:

- *Who lives in our community?*
- *How do members interact to form our community?*
- *How do organisms in the natural world interact to form a community?*
- *How can we interact with our natural environment's resources in a way that is respectful and enduring?*

4. Scientists can discuss these questions out loud or use their notebooks to write or draw their ideas.
5. Tell everyone that later in class they will learn about some Indigenous practices that have been used for many years. These practices show how physics can be used in everyday life!

ACTIVITY 2: PAIR & SHARE (Optional today)

TIME: 5 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16

GOAL: Gauge students' knowledge of today's subject and invite questions

PROCEDURE:

1. Have students retrieve their **notebooks and pencils**.
1. Ask a question that relates to today's subject. Have the scientists answer the question by drawing or writing in their notebooks or simply thinking about it.

Example Questions:

- *How do our eyes work?*
- *Would having eyes on the sides of our heads change the way we see?*

2. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

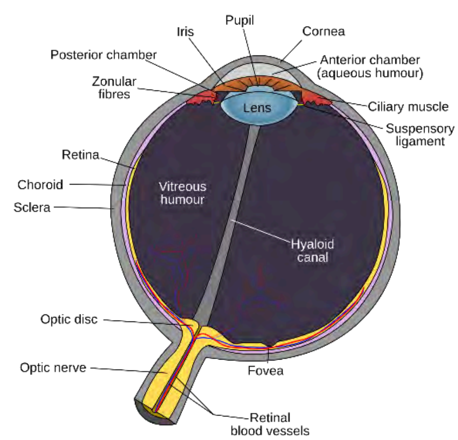
ACTIVITY 3: EYE EXPLORATIONS

TIME: 20 Minutes

SOURCE: *49 Easy Experiments with Optics by Robert W. Wood*

Supplies	#
Cups (9oz, plastic, punch)	4
Lenses, convex	4
Mirrors (2x3in)	16
Newspaper	
Paper Towels (rolls)	1
Pipettes	4
Pitcher	1
Worksheets	**#**
How Lenses Bend Light	2

BACKGROUND:



Your eyes are pretty amazing, and you need them to see color and light! Light passes through the cornea through your pupil. Your pupil is the opening in your eye that lets light in. Your pupil gets larger when you're in a dimly lit space so it can let more light in to see. Your pupil gets smaller when you're in a brightly lit space, limiting the amount of light that gets so your eyes aren't damaged. The iris controls how much light goes through the pupil and through the lens, which focuses the light into a clear picture. The picture from your lens is projected on the back of your eye, the retina, which sends the signal through the optic nerve to your brain! The lens is a convex lens, which means rays of light pass through the lens, then meet at a point. At the point on the other side of the lens, the image is flipped upside-down! The sclera, eyelashes, and mucous protect the other parts of the eye and the capillaries supply the eye with fuel so it can do its job. Vision is so important that seeing uses half of your brain's power! Your eye is a work of art! (bit.ly/3qcyEwY)

SURVEY CONNECTIONS:

★ This activity is linked to the following survey questions:

Q. What happens to light when it passes through things like water or binoculars?

A. The light bends

★ **Q.** Select the hypothesis (Circle one):

A. Mirrors reflect objects and bounce light rays.

GOAL: To learn the parts of the eye and practice observation skills.

WHAT GOES HOME: Nothing

PROCEDURE:

1. Give each student a **mirror** and have them look closely at their eyes in the mirror (Photo 2.1).
2. Emphasize that they are making observations.
3. Have students Pair & Share to discuss their observations and vocalize any questions they might have about their eyes.
4. Have partners watch each other's pupils carefully.

Discussion Prompts:

- *What do you notice about your eyes?*
- *Do you recognize certain parts?*
- *What do you think your pupil does?*
- *Why is your pupil important to your sense of sight?*
- *What happens to your pupil when it's dim inside? What happens when it's bright inside? Do your pupils change in any way?*

5. Ask students to make a hypothesis about what will happen to their pupils when we turn the lights off then on again.
6. Turn off the classroom lights for a few seconds, then turn them back on. Alternatively, you could have students close their eyes for 30 seconds then open them. Partners are watching each other's pupils carefully when the lights come back on (or when they open their eyes). Students may try this again by looking into a mirror so they can see their own pupils change.

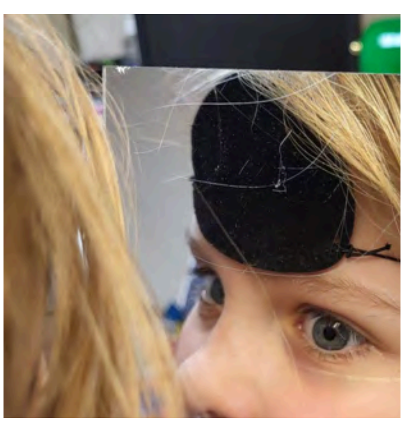
Discussion Prompts:

- *What did you see?*

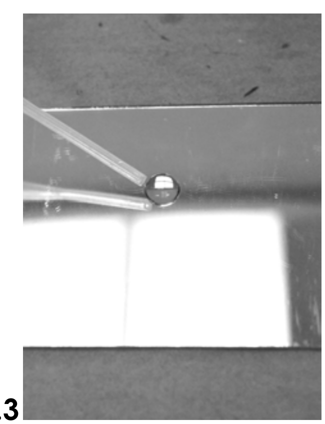
- *Did your pupils get bigger or smaller?*
- *How fast do your pupils respond?*
- *Why does your pupil do that?*
- *Do you think we could see another part of our eye if we look a different way?*

7. Have students look at another student's eye from the side (Photo 2.2). If they look closely, they can see a clear bulge that covers the iris. This is the cornea. The cornea protects the eye and works with the lens (located behind the pupil) to help the eye focus.
8. The lens is inside the eye, behind the pupil. To explore this, put students into four groups. Give each group **one plastic cup half-filled with water (from prep), a pipette, and a sheet of paper towel**. If desired, have scientists place a piece of **newspaper** under their supplies.
9. If students haven't used pipettes before, you might want to have them practice. Have students lift the pipette out of the water then squeeze the bulb over the cup to release air and water. Still squeezing the bulb, have them submerge the tip of the pipette then release the bulb. The pipette should fill up. They can lift the pipette (not squeezing the bulb) above the cup then practice gentle squeezing so that just one drop comes out at a time.
10. Have students use a pipette to place one drop of water onto their mirror near the center (Photo 2.3).
11. Without touching the mirror, have students observe their reflection in the water drop. They may want to move their head and see how their reflection moves. The scientists should notice that their reflection is upside down, because it flipped over the way images did through last week's convex lens. The lens in the eye works the same way!
12. Optional - if you have time you can bring the **convex lenses** and/or the **How Lenses Bend Light worksheet** out to emphasize the concepts in this lesson. Have the scientists compare the way objects look through the convex lens vs the water droplet.

ACTIVITY PHOTOS:

2.1 

2.2 

2.3 

ACTIVITY 4: ARE TWO EYES BETTER THAN ONE?

TIME: 10 Minutes

SOURCE: *Science Works -65 Experiments that Introduce the Fun and Wonder of Science from the Ontario Science Center*

Supplies	#
Cups (Dixie)	8
Eye Patches	16
Pencils	16
Pennies	16

BACKGROUND:

Binocular vision is an adaptation we have that uses two eyes facing forward with overlapping fields of view to provide us with good depth perception. Having two eyes helps us determine the position and distance of things around us. The brain fixes an image with one eye (our dominant eye) and uses the information from the second eye to add dimension and depth. Humans aren't the only animals that use binocular vision. Other animals that use binocular vision are predators. Predators are animals that eat other animals. Some examples are hawks, lions, and wolves. They must be able to see what is in front of them clearly so they can catch their prey.

The Large Binocular Telescope is in Arizona. It looks like a face with two big telescopes for eyes - but this face is 25 yards wide! The two telescopes work together to get a better view of nearby planets, like Jupiter. (bit.ly/44W2swF, bit.ly/3KxcwnF)

GOAL: By using only one eye, we can demonstrate why the depth perception provided by having two eyes is important.

WHAT GOES HOME: Penny, eye patch

PROCEDURE:

1. Pair students.
2. Give each student an **eye patch and a pencil**.
3. Give each pair **two pennies and a Dixie cup.** Have each pair set the cup on a table.
4. Have one member in each pair stand about 9 feet away from the table.
5. Have the other member hold a penny as high as they comfortably can somewhere over the cup, but not directly above it (Photo 2.4).

6. Tell students that the job of the person standing back from the table is to look at the penny and tell their partner where to move their arm so the penny will fall into the cup when they drop it. The person giving directions must cover one eye with their eye patch (Photo 2.5).
7. The person giving directions can use phrases like, "towards me," and "away from me," and point to their right or left to tell their partner where to move the penny.
8. The partner moving the penny should move slowly and smoothly, like a claw machine. To resist helping their partner, they should look only at their partner, and not how close the penny is to the cup.
9. The partner giving directions can say, "Drop it!" when they think the penny is in line with the cup. Have students repeat with the second penny.
10. Have students repeat the activity using the other eye.
11. Have students give instructions with both eyes open.
12. Have students switch roles and repeat the activity.

Discussion Prompts:

- *Which was easier: using one eye or both eyes?*
- *Why do you think we have two eyes?*
- *When is it useful to be able to judge position and depth?*

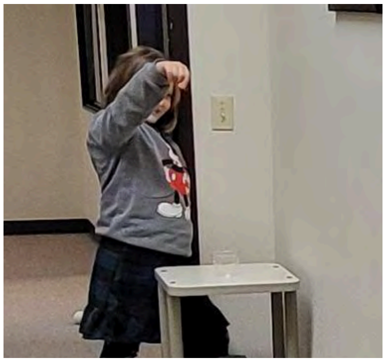
OPTIONAL:

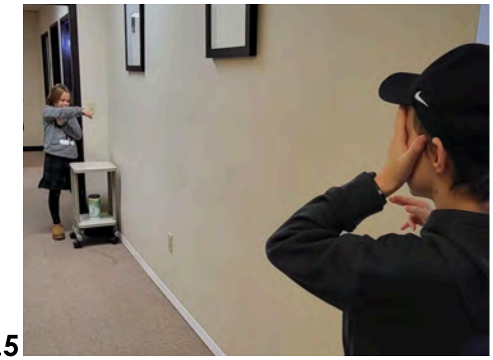
1. Tell students that even though our eyes work together, one eye is usually dominant.
2. Ask students to make a hypothesis about which eye they think is their dominant eye.
3. Have students make a circle with their thumb and index finger.
4. Focus on an object in the distance (like a corner of the ceiling).
5. While focusing on the object in the distance, move their finger circle so the object is in the middle of the circle.
6. Without moving their finger circle, use their other hand (or the eye patch) to cover one eye and see what happens. Then try the other eye.
7. Most people's right eye is dominant, meaning that the right eye will show the object in the middle of the circle.

Discussion Prompts:

- *What happened?*
- *Which eye was dominant?*
- *Why do you think we have a dominant eye?*
- *What are some other ways we could test for eye dominance?*
- *When might it be important to know which eye is dominant?*

ACTIVITY PHOTOS:

2.4 

2.5 

ACTIVITY 5: 3D!

TIME: 20 Minutes

SOURCE: www.rainbowsymphony.com

Supplies	#
3D Glasses	16
Crayons (black)	4
Crayons (blue)	4
Crayons (box)	1
Crayons (red)	4
Scissors (site provides)	16
Worksheets	**#**
3D Images (double-sided half sheets)	16
Paper (8.5inx11in, sheets, white)	16
Secret Decoder Message (quarter sheets)	16

BACKGROUND:

3D glasses can work in a few different ways. The ones in this activity have a red lens and a blue lens. This blocks either red or blue colors from your eyes. By creating the same image in two different colors and looking at it through these glasses, it forces your eyes to see two different images. This mimics what your eyes would see in real life, with each eye seeing a slightly different perspective or image. Your brain doesn't know it's being tricked, so it translates the two images into a 3D picture.

You can see 3D images in lots of different ways. Some 3D glasses use polarized filters; light waves move in different directions – some waves move up and down, and other waves move side to side.

By blocking one or the other, polarized glasses can force your eyes to see a different image in each eye, so things look 3D. (bit.ly/47oBolk)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. Select the hypothesis (Circle one):

A. Mirrors reflect objects and bounce light rays.

GOAL: To understand how colored filters affect what we see using 3D glasses.

WHAT GOES HOME: 3D glasses, 3D Image worksheet, Secret Decoder Message worksheet, Any drawings

PROCEDURE:

1. **Tell Students:** Valerie Thomas is a Black data analyst who was working for NASA when she invented a way to transmit 3D images onto a screen. Without this technology, we wouldn't have 3D movies! Let's explore how our eyes can see images in 3D, just like Dr. Thomas.
2. Give each scientist a pair of **3D glasses,** if they don't fit well on students' faces, have students simply hold the glasses in front of their eyes.

   Discussion Prompts:

   - *Have you ever used 3D glasses before?*
   - *How do you think they work?*

3. Have students close (or cover) one eye and look only through the red lens while exploring the room (Photo 2.6).
4. Point out some things in the room that are red, orange, yellow and white and have students look at them through the red lens. Discuss with the students what they see.
5. Have students look at the same items through the blue lens, and again discuss what they see.

   Discussion Prompts:

   - *What happens when you look at objects that are the same color as the lens you're looking through?*
   - *What about objects the opposite color of the lens? Why?*

6. Point out some things in the room that are blue, turquoise, and green, and have students look at the items through the blue lens and discuss what they see.

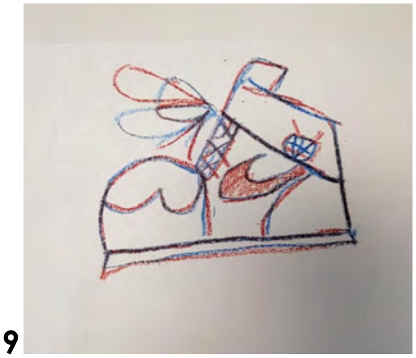
7. Have students look at the same items through the red lens and discuss what they see.
8. Give each student a **Secret Decoder worksheet**.
9. Have students close one eye so they look only through the blue lens, then discuss what they see (Photo 2.7).
10. Have students look at the picture through the red lens, then discuss what they see (Photo 2.8).
11. Have students remove their 3D glasses in preparation for the next step.
12. Give each scientist a **3D Images worksheet**, have them examine it without the 3D glasses on, and make a <u>hypothesis</u> about what they will see with the glasses on.
13. Have students look at the worksheets through their 3D glasses. Note: the rock landscape can be slightly challenging to see. Students may need to adjust the focus of their eyes and/or hold the paper further away from them.
14. Have the students discuss what they see and consider what features of the image work to make it appear 3D when seen through the glasses.
15. Explain that when your right eye looks at the 3D drawings through the blue filter, the red/orange part of the picture looks black, and the blue part disappears. When your left eye looks at the drawing through the red filter, the blue part of the drawing looks black, and the red part disappears. This means your right eye sees one black drawing, while your left eye sees a slightly different black drawing. Your brain merges the two together to make a single 3D image.
16. Hand out the **crayons** and give each student **a sheet of paper**. Have students try to make their own secret decoder messages and/or 3D images. Once they've finished creating their own image, have students share/pass around what they've made and try out their glasses on different illusions (Photo 2.9)!

<u>ACTIVITY PHOTOS:</u>

2.6

2.7

2.8


2.9

ACTIVITY 6: DAILY DEBRIEF

TIME: 5 Minutes

GOAL: Reflect on what was explored during the activities and relate to students' own lives.

PROCEDURE:

1. Gather students in a circle.
2. Ask questions that facilitate a thoughtful reflection of the day's lessons. Questions may be considered in a Pair & Share model.
3. If you are short on time, have students think about the questions while they are cleaning up from the activities.

Example questions:

- *What happened today?*
- *How does 3D work?*
- *What was a challenge that you overcame?*
- *What would we do if we had more time?*
- *How does what we learned today apply to your personal life?*

CLEAN UP: Implement a fun, daily clean-up routine so that students practice being "truly helpful" to their AKA Science community.

WHAT TO SAVE: Some items will carry over into future classes and others will require proper disposal. We have created a table to help organize your materials by when they will be used again. If an item has a number in the column marked "move to:", all the items used today should be moved to the new class bag. If marked "send home", the items are to go home with your scientists. "Save for SUN, recycle, or discard" means the items can be kept for use by your site or discarded as needed.

Supplies	Move to:	Send home	Save for SUN, recycle, or discard
3D glasses		X	
Crayons, black	Class 3		
Crayons, blue	Class 3		
Crayons, box	Class 3		
Crayons, red	Class 3		
Cups, 9oz punch	Class 7		
Cups, dixie	Class 4		
Eye patches		X	
Lab notebooks	Class 3		
Lenses, convex			X
Mirrors, 2x3in	Class 5		
Newspaper, bundle	Kit box		
Paper towels, roll	Kit box		
Pencils	Class 3		
Pennies		X	
Pipettes	Class 4		
Pitcher	Kit box		
Scissors (site provides)			X
Water			X
Worksheets			
3D Images (double-sided half sheets)		X	
How Lenses Bend Light	Envelope		
Paper (8.5inx11in, sheets, white)		X	
Secret Decoder Message (quarter sheets)		X	

GRAND TOTAL OF WHAT GOES HOME: Pennies, eye patches, 3D Glasses, and 3D worksheets/drawings.

******If any new scientists joined your class this week, remember to send home the Supply Advisory and Consent Form for Publication with each student.******

CLASS 3: ILLUSTRIOUS ILLUSIONS

Supplies (in class bags)	#
Crayons, black	4
Crayons, blue	4
Crayons, box	4
Crayons, red	4
Glue, bottles or sticks	4
Lab notebooks	16
Pencils	16
Pushpins	4
Rulers, plastic	4
Scissors (site provides)	16
Tape, rolls Scotch	4
Wooden tops	16
Yarn, 4ft loops	16
Worksheets (in envelope)	**#**
Agamograph picture	16
Benham's Disk, cardstock quarter sheet	16
Fishbowl Thaumatrope, cardstock half sheet	16
Labeled template	16
Paper, white ½ sheet	16

PREP STEPS:

- **Act 3. (optional):** Unwrap and assemble wooden tops.

VOCABULARY:

- **Afterimage:** An impression of a visual image retained after the stimulus has ceased (e.g. closing your eyes, looking away).
- **Illusion:** A thing that is or is likely to be wrongly perceived or interpreted by the senses.
- **Persistence of vision:** The retention of a visual image for a short period of time after the removal of the stimulus that produced it: the phenomenon that produces the illusion of movement when viewing motion pictures.
- **Thaumatrope:** A disk with a picture on each side is attached to two pieces of string. When the strings are twirled quickly between the fingers the two pictures appear to blend into one.

ACTIVITY 1: PAIR & SHARE

TIME: 5 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16

GOAL: Gauge students' knowledge of today's subject and invite questions

PROCEDURE:

1. Pass out **a notebook and a pencil** to each scientist.
2. Ask a question that relates to today's subject. Have the scientists answer the question by drawing or writing in their notebooks or simply thinking about it.

   Example Questions:
   - *Have you ever seen an optical illusion before?*
   - *How do you think cartoons were made before computers?*

3. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

ACTIVITY 2: FISHBOWL THAUMATROPE

TIME: 15 Minutes

SOURCE: *The Exploratorium Science Snackbook* by The Exploratorium Teacher Institute, *Science Works-65 Experiments that Introduce the Fun and Wonder of Science* from the Ontario Science Center

Supplies	#
Crayons (blue)	4
Crayons (box)	1
Crayons (red)	4
Scissors (site provides)	16
Tape (rolls, Scotch)	4
Yarn (4ft loops)	16
Worksheets	**#**
Fishbowl Thaumatrope	16

BACKGROUND:

Your eye and brain hold onto a visual image for about 1/30th of a second - scientists call this phenomenon persistence of vision, because an image persists in our vision even after we can't see it anymore. The effect of the images on a thaumatrope combining happens because of persistence of vision. When you see one of the pictures, your eye holds onto that image for a fraction of a second, even after you spin the disc to see the other picture. As you keep spinning the disc, your brain blends each image with the next one, which makes it look like you're seeing them both at the same time!

Persistence of vision inspired the invention of animation! By flashing images quickly one after the other, animators fool your brains into thinking that you're seeing a moving image, or "motion picture," as movies were originally called. Disney's 1989 version of *The Little Mermaid* is made up of over one million drawings! (bit.ly/3DOfWyB)

GOAL: To introduce the concept of persistence of vision using a thaumatrope.

WHAT GOES HOME: Fishbowl Thaumatrope

PROCEDURE:

1. Give each student a **Fishbowl Thaumatrope worksheet, a pair of scissors, and a 4ft yarn loop**. Make **crayons** and **tape** available.

   Discussion Prompts:

   - *Have you ever seen an optical illusion before?*
   - *How do you think optical illusions work?*

2. Have students:
   a. Use a blue, red or green crayon to color the fish on the worksheet. Fill in the shape with color completely, so it is a brilliant, solid color.
   b. Stare intently at the black dot of the fish's eye for about 30 seconds.
   c. Quickly look at the empty fishbowl on the worksheet.
   d. Discuss what happens! Students should see an afterimage of the fish in the bowl in the opposite color to the one they colored with.

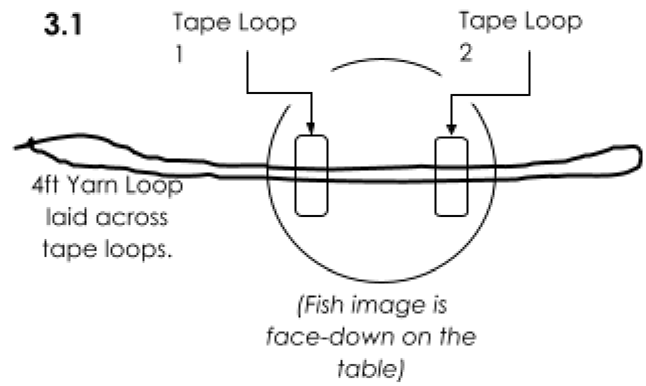
   Discussion Prompts:

   - *What happens after staring at the black dot and looking away? What do you see?*
   - *Why do you think afterimages happen?*

3. Explain that afterimages happen because our eyes have different types of sensors. Each sensor is responsible for detecting a particular type of color. If you focus on a single color for too long, those specific color sensors can become tired, so other sensors take over when you look away.

4. <u>Have students</u>:
    a. Cut out the fish and bowl circles along the border.
    b. Flip the fish circle over.
    c. Make two tape loops (sticky on both sides) and place one on each side of the circle (Diagram 3.1).
    d. Lay the yarn loop across the tape loops. The yarn loop should be centered in the middle of the circle with the knot to one side. Make sure the yarn lines up with the lines at the edges of the circles (Diagram 3.1).
    e. Place the bowl circle face-up on the tape loops so the image of the bowl is upside-down. The stars on the fish and bowl circles should be in the same position (i.e., both at the top) (Photo 3.1).
    f. Press the circles together to make sure the tape sticks to both circles.

3.1

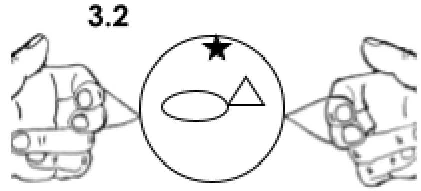


<u>Discussion Prompts:</u>

- *How do you think cartoons were animated before computers?*
- *How is the effect of our thaumatrope similar to animation?*

5. Introduce this device as a <u>thaumatrope</u>. Thaumatropes were invented thousands of years ago. More recently though, they helped to inspire the first animations.
6. Show students how to use the thaumatrope:
    a. Hold one loop of string in two fingers of each hand (see diagram).
    b. Twirl the thaumatrope in circles (10-12 times) to wind it up, then pull your hands apart (still holding the loops) to make the yarn quickly unwind (Diagram 3.2).
    c. Have the students discuss what they see!

3.2

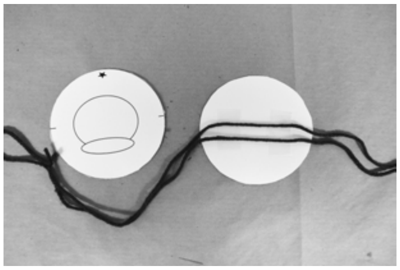


Twirl the thaumatrope to wind it up, then pull gently outward to make the fish appear inside the bowl.

<u>Discussion Prompts:</u>

- *What happens when you unwind your thaumatrope quickly? What do you see?*
- *Why do both of the images appear to combine into one when they spin?*

ACTIVITY PHOTOS:

3.1 

ACTIVITY 3: NOT IN KANSAS ANYMORE

TIME: 10 Minutes

SOURCE: Awesome Experiments in Light & Sound, Michael DiSpezio and Catherine Leary

Supplies	#
Pushpins	4
Scissors (site provides)	16
Tape (rolls, Scotch)	4
Wooden tops (spinners)	16
Worksheets	**#**
Benham's Disk (quarter sheets)	16

BACKGROUND:

The "Artificial Spectrum Top" invented by C.E. Benham was first released in 1894 as a toy to study optics. The disc is special because its rotating black and white pattern fools the viewer's brain into seeing color! Scientists are still debating why our brains perceive color in these circumstances. One of the top theories is related to persistence of vision and suggests the alternating black/white pattern triggers our eye's color sensors into thinking we're seeing color. Other Benham patterns are available online. Try them out and see what colors they reveal! (bit.ly/3OLgVWC)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. Select the hypothesis (Circle one):

A. Mirrors reflect objects and bounce light rays.

GOAL: To show how the brain can be tricked into seeing black and white as color using Benham's Disk.

WHAT GOES HOME: Benham's Disk on wooden top

PROCEDURE:

1. Give each student a **Benham's Disk worksheet**. Make **scissors** available.
2. Have students cut out the disk as well as they can. The experiment works best with a perfect circle but will still work with slight unevenness.

   Discussion Prompts:

   - *What do you see when you look at this disk? What do you think we might use it for?*
   - *What might we see if we spin the disk very fast?*

3. Give each student one **wooden top** and invite them to practice spinning their top a few times in each direction.
4. Make **pushpins** and **scotch tape** available. Have students gently poke their wooden spinners through the center of the paper Benham's Disk, so that the disk comes to rest on the topside of the spinner's base. The pushpins can be used to start a central hole on the paper disk, if students have trouble using the spinner to poke the hole. Tape can be used to secure the disk to the wooden spinner base, if the fit is not snug enough (Photo 3.2).
5. Have the students hypothesize about what they think they'll see when they spin their wooden tops, then invite them to give their tops a whirl. Ask them to focus on the black bands and see if anything changes. Note that in order to see the effect, they will have to spin it consistently, evenly and pretty quickly. If some students are struggling, have them observe a student who has a consistent spin.
6. Encourage your students to try spinning their top in both directions (clockwise and counter-clockwise) and note any differences.

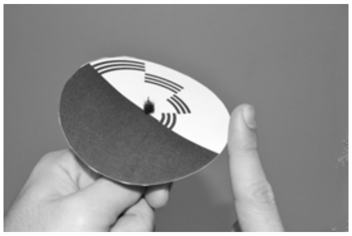
   Discussion Prompts:

   - *Do you observe any differences when you spin the disk in the opposite direction?*
   - *Why do you think we see colors when there aren't any?*
   - *Do you think other patterns might create similar effects or optical illusions?*

OPTIONAL:

If there is extra paper readily available in your classroom, students are free to cut out their own blank disks to decorate or attempt to design their own optical illusion pattern to put on their wooden top and see what happens!

ACTIVITY PHOTOS:

3.2 

ACTIVITY 4: OMG AGAMOGRAPHS!

TIME: 15 Minutes

SOURCE: bit.ly/4534YBy and Karley Schlaht, AKA Science

Supplies	#
Crayons, black	4
Crayons, blue	4
Crayons, box	4
Crayons, red	4
Glue, bottles or sticks	4
Scissors (site provides)	16
Worksheets	**#**
Agamograph pictures	16
Labeled templates	16

BACKGROUND:

Agamographs, or lenticular images, are optical illusions that combine multiple pictures that change depending on the angle of view. This art style was named after the artist Yaacov Agam who was famous for his kinetic (moving) art. Many lenticular images are printed using plastic ridges called lenticules over a printed background layer, but we can create a two-picture Agamograph with paper, scissors, and glue. The paper image won't have as much movement as the plastic one, but it will still show two completely different images, depending on how you look at it! (bit.ly/44lzZiZ)

GOAL: To create an optical illusion called an Agamograph

WHAT GOES HOME: Finished Agamograph

PROCEDURE:

1. **Tell the class:** A Jewish Middle Eastern artist, Yaacov Agam, invented the type of art we are going to do today. This art is called an Agamograph, and it uses paper folding to give the illusion of different unbroken pictures, depending on how you look at it. Let's be artists like Mr. Agam and make Agamographs.
2. Group scientists into sets of four. Hand out a **box of crayons, scissors, and a ruler** to each group.
3. Give each scientist a **labeled background template** (Photo 3.3) and a **printed Agamograph picture** (Photo 3.4).

Discussion Prompts:

- *Have you ever seen a sticker or a poster that changes pictures depending on how you look at it?*
- *How do you think that happens?*

4. Have scientists color in the printed worksheet. It works best if one picture uses warm colors (red/orange/yellow) and the other uses cool colors (green/blue/purple), but that isn't necessary.
5. Once the picture is colored in, scientists should cut along the solid lines only of the worksheet. This will result in four strips of paper for each picture (Photo 3.5).
6. Scientists should then line up the strips onto the background sheet, matching the letter/number combinations in order: A1, B1, A2, B2, A3, B3, A4, B4 (Photo 3.6).

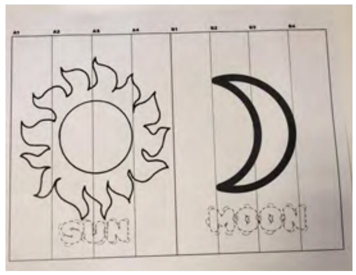
Discussion Prompts:

- *What do you think we are going to do with the picture now that it is cut up?*
- *What is your hypothesis about how this will become an optical illusion?*

7. Once the strips are arranged, have the scientists glue their strips onto the background sheet (Photo 3.7).
8. Once the strips are glued to the paper, fold along the borders of the picture strips accordion-style (Photos 3.8 - 3.9).
9. Crease folds, then pull the sheet open so that it stands on the table. Angle it so that you can see all of one picture. If you turn it to the other side, you will see the other picture (Photos 3.10 - 3.11).
10. If desired, the tabs labeled A1, B1, etc., can be cut off (Photo 3.12).

ACTIVITY PHOTOS:

3.3


3.4


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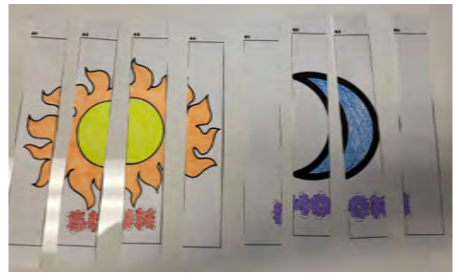

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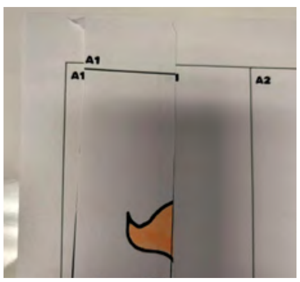

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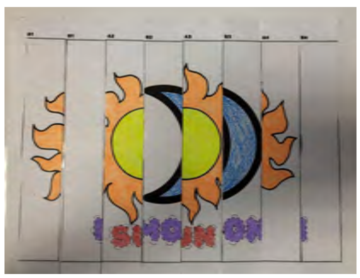
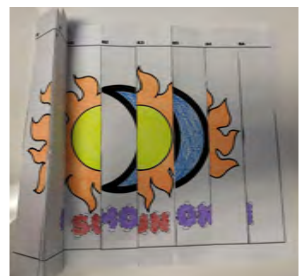


3.8


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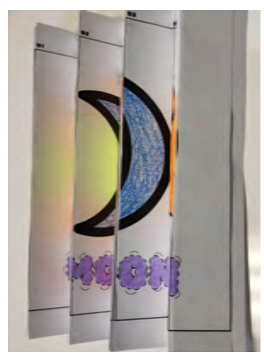


3.12


ACTIVITY 5: 3D ILLUSION DRAWINGS

TIME: 10 Minutes

SOURCE: bit.ly/3s9raLL

Supplies	#
Crayons, black	4
Crayons, blue	4
Crayons, box	4
Crayons, red	4
Pencils	16
Rulers, plastic (optional)	4
Worksheets	**#**
Paper, ½ sheet white	16

BACKGROUND:

Even though we are 3-dimensional beings in a 3-dimensional world, our eyes are only capable of seeing in 2-D. Our brains take the 2-D image that we see and project the illusion of 3-D by adding depth to objects. This is why binocular vision is so useful - without two eyes your brain has a harder time projecting depth onto the objects you look at. We can use the brain's ability to interpret depth to deceive ourselves into seeing a 2-D drawing as a 3-D object, using a little creativity and a simple drawing trick. (bit.ly/3qK55TC)

GOAL: To make a drawing of a simple object appear 3D.

WHAT GOES HOME: 3D Drawings

PROCEDURE:

1. Gather scientists into four groups. Pass out **a half sheet of white paper and pencil** to each scientist.
2. Provide each group with **a ruler and a box of crayons** to share.

   Discussion Prompts:

   - *Do you remember testing out 3D glasses in the first class? What happened?*
   - *Can you think of another way we can see things in 3D?*

3. Have scientists draw a simple shape on their paper, an oval or triangle works well. They should sketch lightly with pencil and leave room all around the outside of the shape (Photo 3.13).

4. Starting at one far edge of the paper, scientists should draw a straight line across the paper until they reach the shape, using a dark colored crayon. They will then draw a smooth curve from one end of the shape to the other. Finally, draw a straight line from one side of the shape to the other far side of the paper. Rulers can be used, but it is not necessary to have perfectly straight lines (Photos 3.14 - 3.15).

TIP: If desired, scientists can use the rulers to make their lines straight. This is not required for an effective drawing! If preferred, scientists can only draw the straight lines at first and then go back and fill in all the curved lines at once.

5. Move slightly up the paper and repeat the process over and over until the paper is covered (Photos 3.16 - 3.17). **It will help to demonstrate this on a chalkboard or whiteboard.**

TIP: don't make the lines too close together, or it will take a long time to complete!

6. Erase any remaining pencil lines, then the drawing is complete!

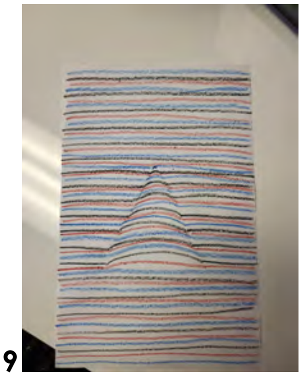
   <u>Discussion Prompts:</u>

   - *Do your pictures look like they are in 3D? Why or why not?*
   - *Do you think the color or thickness of the lines makes a difference?*

7. **<u>OPTIONAL:</u>** (if there is time and interest, you can add the following steps):
   - Add additional stripes of color in between the original lines (Photos 3.18 - 3.19).
   - Try another drawing in a different size or line color.
   - Have students lightly trace their hands and use that to make a 3D drawing (Photo 3.20).

<u>ACTIVITY PHOTOS:</u>

3.13  **3.14**  **3.15**  **3.16** 

3.17  3.18  3.19  3.20 

ACTIVITY 6: DAILY DEBRIEF

TIME: 5 Minutes

GOAL: Reflect on what was explored during the activities and relate to students' own lives.

PROCEDURE:

1. Gather students in a circle.
2. Ask questions that facilitate a thoughtful reflection of the day's lessons. Questions may be considered in a Pair & Share model.
3. If you are short on time, have students think about the questions while they are cleaning up from the activities.

Example questions:

- *What happened today?*
- *What did you learn about optical illusions?*
- *What would we do if we had more time?*
- *How does what we learned today apply to your personal life?*

CLEAN UP: Implement a fun, daily clean-up routine so that students practice being "truly helpful" to their AKA Science community.

WHAT TO SAVE: Some items will carry over into future classes and others will require proper disposal. We have created a table to help organize your materials by when they will be used again. If an item has a number in the column marked "move to:", all the items used today should be moved to the new class bag. If marked "send home", the items are to go home with your scientists. "Save for SUN, recycle, or discard" means the items can be kept for use by your site or discarded as needed.

Supplies	**Move to:**	**Send home**	**Save for SUN, recycle, or discard**
Crayons, black	Class 6		
Crayons, blue	Class 6		
Crayons, box	Class 6		
Crayons, red	Class 6		
Glue, bottles or sticks			X
Lab notebooks	Class 4		
Pencils	Class 4		
Pushpins	Class 4		
Rulers, plastic	Class 5		
Scissors (site provides)			X
Tape, rolls Scotch	Class 4		
Wooden tops		X	
Yarn, 4ft loops		X	
Worksheets			
Agamograph picture		X	
Benham's Disk, cardstock quarter sheet		X	
Fishbowl Thaumatrope, cardstock half sheet		X	
Labeled template		X	
Paper, white ½ sheet		X	

GRAND TOTAL OF WHAT GOES HOME: Fishbowl Thaumatrope, Bentham's Disk paper cutout on wooden top, Agamograph, 3D drawings.

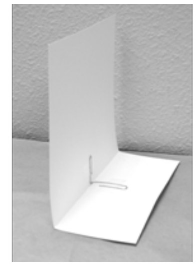
CLASS 4: LIGHT SPLITTING

Supplies (in class bags)	#
Colored filters, blue	16
Colored filters, red	16
Colored filters, yellow	16
Cups, 10oz	8
Cups, 20oz	1
Cups, calibrated, 1oz	1
Cups, Dixie	4
Lab notebooks	16
LED flashlights	4
LED lights, blue	4
LED lights, red	4
LED lights, white	4
Markers, black washable	2
Paperclips, jumbo	8
Pencils	16
Pipettes	4
Pitcher – *in kit box*	1
Plastic sheeting, black 4x4in squares	16
Powdered milk (bag)	1
Prisms, teardrop	8
Prisms, triangular	8
Pushpins	4
Rainbow viewers	16
Rubber bands, size 16	16
Scissors (site provides)	16
Spoon	1
Tape, Scotch rolls	4
Water (oz)	47.5
Worksheets (in envelope)	**#**
Color Wheel	2
Paper, cardstock, white	8
Paper, construction, black	16

Fun Physics: Color & Light (Grades 3-5)

Class 4: Light Splitting

PREP STEPS:



- **Act. 2:** For each of the pieces of white cardstock, fold the bottom 1/3 inward. Bend each paperclip to form an "L" shape. Tape one paperclip to the inside fold of each piece of cardstock so the square stands upright, supported by the clip (see photo right). These are your cardstock walls.
- **Act. 4a:** In the 20oz cup, use the calibrated cup to add 7.5oz of water to the milk powder. Stir with the spoon until milk powder is dissolved. Divide the milk into 4 Dixie cups.
- **Act. 4b:** Fill eight 10oz plastic cups about ¾ full of water. With the black marker, label four of the cups "experimental" and the other four "control". Make sure to write near the top rim of the cups.

VOCABULARY:

- **Diffraction:** The bend or spreading of light waves around obstacles.
- **Prism:** A three-dimensional solid object in which the two ends are identical. It is the combination of the flat faces, identical bases and equal cross-sections.
- **Rainbow:** An arch of colors formed in the sky in certain circumstances, caused by the refraction and dispersion of the sun's light by rain or other water droplets in the atmosphere.
- **Refraction:** Change in direction of a wave as a result of its traveling at different speeds, generally caused by passing through a medium (e.g. glass, plastic, water, air).

ACTIVITY 1: PAIR & SHARE

TIME: 5 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16

GOAL: Gauge students' knowledge of today's subject and invite questions

PROCEDURE:

1. Pass out **a notebook and a pencil** to each scientist.
2. Ask a question that relates to today's subject. Have the scientists answer the question by drawing or writing in their notebooks or simply thinking about it.

Example Questions:

- *Where can you find rainbows in nature?*
- *What causes those rainbows?*

3. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

ACTIVITY 2: PRISM EXPLORATION

Note: This activity is best done on a sunny day

TIME: 15 Minutes

SOURCE: bit.ly/3Yunwbo

Supplies	#
LED Flashlights (3-bulb)	4
Paper (cardstock, 8.5inx11in) – *cardstock wall from prep*	8
Paper Clips (jumbo) – *cardstock wall from prep*	8
Prisms (acrylic, triangular)	8
Prisms (crystal, teardrop)	8

BACKGROUND:

When light passes from the air into glass, it slows down, and when it leaves the glass, it speeds up again. If the light hits the glass at an angle instead of dead-on, it undergoes refraction—or bending. The angle at which it hits the glass is not the same as the angle it travels inside the glass. The light is no longer moving in a straight line but gets bent at the surface. The same thing happens when the light leaves the prism--it bends again.

We've already learned that white light is made up of many different colors of light. The different colors of light, from red to violet, each get bent at slightly different angles. Different colors of light each have a different index of refraction. Red gets bent the least, violet the most. This causes the colors to fan out and become distinct. However, not all light that we think of as "white" contains the full spectrum of colors. Fluorescent and LED bulbs that we frequently rely on for indoor light only contain a few distinct wavelengths. So, when these types of light are diffracted through a prism, a rainbow won't appear. Sunlight, however, always contains the full spectrum of visible light colors.

In the 1600s, Isaac Newton did a series of experiments with prisms and light. The fact that a prism can break light into colors was known before Newton. But Newton asked what would happen if he put a second prism in the location of the colors. If the second prism caught all the colors on one of its surfaces, white light came out of the other side. The same properties that spread the colors apart worked in reverse to reassemble them. Newton also asked what would happen if he used a second prism on only one color. Would it break into other colors? His experiment showed that it didn't. The colors coming out of a prism are fundamental. (bit.ly/3KAGRlw)

SURVEY CONNECTION:

★ This activity is linked to the following survey questions:

Q. White light can be split into a rainbow.

A. Yes

★ **Q.** What happens to light when it passes through things like water or binoculars?

A. The light bends

GOAL: To explore the properties of prisms, illustrate how prisms bend light, and refract white light to display rainbows.

WHAT GOES HOME: Acrylic triangular OR crystal teardrop prism (decided among each pair which student takes home which)

PROCEDURE:

1. Pair students up and give each pair **one acrylic triangular prism and one crystal teardrop prism**.
2. Have the students explore and compare the two prims. Encourage the students to look through the prisms around the room and discuss what they see with their partner.
3. If lined paper, or paper with text printed on it is available, have students experiment with putting the triangular prism on the paper and rotating it slowly. The lines or text on the paper should look angled instead of straight across when viewed through the prism (Photo 4.1).
4. Put students into groups of four and pass out **a 3-bulb LED flashlight and cardstock "wall"** from prep to each group.
5. Encourage the students to come up with a hypothesis for what will happen when they shine the flashlight at each of their prisms.
6. Have students experiment with their flashlight, cardstock, and prisms. It may help to dim lights in the classroom so that students can more clearly see what happens with their flashlight beam.
7. Encourage students to:
   - Move around and rotate their prisms in relation to the flashlight beam.
   - Test different distances between the light and the prism.

- Combine multiple prisms to see what happens.
- Use the cardstock "wall" to catch the light being reflected and <u>refracted</u> through the prisms. Placing the cardstock flat on the table with a prism on top of the cardstock, or held just above, can yield some particularly interesting results.

<u>Discussion Prompts:</u>

- *What do you see when you look around the room through each prism?*
- *What do you think will happen when you shine a light through these different prisms?*
- *What colors can you see being refracted out from the flashlight? Is it the whole rainbow?*

8. Results may vary, but the crystal teardrop prism should scatter the light into many different reflections (similar to a disco ball). Small lines of orange and blue may be visible at the edges of each individual light fragment depending on the angle of refraction (Photo 4.2).
9. The acrylic triangular prism will also display the orange and blue color spectrum of the LED light, but in one continuous arch (Photo 4.3).
10. If the sun is visible through a classroom window, you can relocate your students to be nearby the window. If not, you should move your class to a sunny area outside.
11. Make sure the students bring their cardstock "walls" and prisms with them.
12. EMPHASIZE THAT **NOBODY SHOULD LOOK DIRECTLY AT THE SUN**, NOT EVEN THROUGH A PRISM!

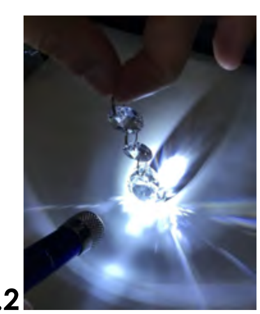
<u>Discussion Prompts:</u>

- *What do you think will happen when sunlight passes through these prisms?*
- *What colors can you see being refracted out from the sunlight? Is it the whole rainbow?*
- *How is the sunlight different from a flashlight?*

13. Have the students experiment with trying to "capture" a ray of sunlight in one of the prisms. See if they can aim their light beam at a piece of cardstock, to get a better picture of the result.
14. If successful, students should be able to observe complete <u>rainbows</u> being refracted!
15. Encourage students to discuss any differences observed between sunlight and their flashlights.
16. Return to the classroom and collect the flashlights from your students.
17. Make sure to hold onto the cardstock "walls" for use in future classes.

<u>ACTIVITY PHOTOS:</u>

4.1



4.2

4.3

ACTIVITY 3: SPECTROSCOPE

TIME: 20 Minutes

SOURCE: bit.ly/3qiCW60

Supplies	#
Colored Filters (blue)	16
Colored Filters (red)	16
Colored Filters (yellow)	16
Pencils	16
Plastic Sheeting (black, 4inx4in squares)	16
Pushpins	4
Rainbow Viewers	16
Rubber Bands (size 16)	16
Scissors (site provides)	16
Tape (rolls, Scotch)	1
Worksheets	**#**
Color Wheel	2
Paper, construction, black	16

BACKGROUND:

A spectroscope is a device that separates light into its individual colors in a rainbow-like band called a spectrum. Spectroscopes are used by scientists to send a single beam of color through a sample. A beam of white light is sent through a diffraction grating, like the rainbow viewer, then filtered for a specific color, and what comes out of the other end is a single-color light, just like you'll see through your spectroscope. (bit.ly/441cR9k)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. White light can be split into a rainbow.

A. Yes

GOAL: To observe that white light can be split into colors and filtered by making a simple spectroscope.

WHAT GOES HOME: Spectroscope, Colored filter (blue,) Colored filter (red,) Colored filter (yellow)

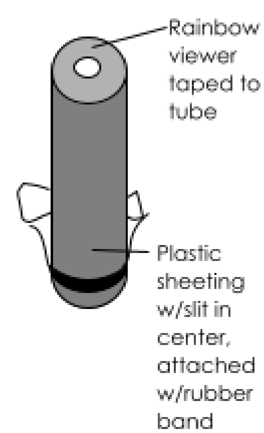
PROCEDURE:

1. Give each student a **rainbow viewer**. Have them look through it at a shiny surface or a light bulb. ***Do not*** *aim the rainbow viewer directly at the sun.*
2. Explain to the students that the rainbow viewers have hundreds of tiny lines scratched into the plastic lenses. These scratches force white light to travel through tiny openings between the scratches. The different colors that make up white light exit the scratches at different angles, in a process called diffraction. Similar to the refraction that bends and separates light colors within a prism, diffraction shows us a rainbow.

   Discussion Prompts:

   - *When we used just the rainbow viewers, could you clearly see each band of the rainbow? Why or why not?*
   - *How could we modify the viewer to be able to focus on one rainbow at once?*

3. Give each student **a sheet of 8.5”x11” black construction paper, a piece of black plastic sheeting, a pencil, and a rubber band**. Make **tape** and **pushpins** available.
4. Have students:
   a. Roll the black construction paper the short way into a tube. The diameter of the tube should be slightly smaller than the diameter of the rainbow viewer.
   b. Tape the tube so that it will hold its shape.
   c. Use a sharpened pencil or pushpin to poke through the center of the plastic sheeting.
   d. Poke a pair of scissors into the hole and cut a small, narrow slit (about half an inch long) (Photo 4.4).
   e. Place the plastic sheeting over one end of the tube so that the slit is centered over the opening of the tube.
   f. Secure the plastic to the tube with a rubber band (Photo 4.5).
   g. On the other end of the tube, tape the rainbow viewer over the circular opening (Photo 4.6).



5. Have students look through the rainbow viewer end of the tube and describe what they see. **DO NOT AIM THE SPECTROSCOPE DIRECTLY AT THE SUN.**

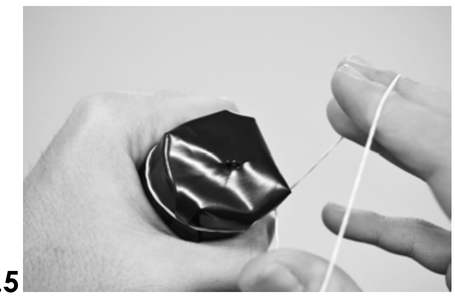
   Discussion Prompts:

   - *What do you see when you point your spectroscope at a bright light?*
   - *What is the purpose of the small slit?*
   - *What do you think will happen to what you see through your spectroscope when we put a color filter in front of the viewer? Why?*

6. Give each student **three colored filters: one red, one yellow, and one blue**, and remind students of the significance of primary colors.
7. Have students hold one of the colored filters in front of the slit as they aim the slit toward a bright light and continue looking through the rainbow viewer.
8. Have students test the different filters individually, then in combinations, and discuss what they see.

ACTIVITY PHOTOS:

4.4 

4.5 

4.6 

ACTIVITY 4: SUNSET

TIME: 15 Minutes

SOURCE: *The Science Book of Color* by Neil Ardley

Supplies	#
Cup (1oz, calibrated)	1
Cups (10oz, plastic, tall)	8
Cups (20oz, plastic)	1
Cups (Dixie)	4
LED Lights (blue)	4
LED Lights (red)	4
LED Lights (white)	4
Markers (black, washable)	2
Newspaper	1
Paper (cardstock, 8.5inx11in) - *cardstock wall from prep*	8
Paper Clips (jumbo) - *cardstock wall from prep*	8
Pipettes	4
Pitcher	1
Powdered Milk (oz)	2.5
Spoons (plastic)	1
Tape (rolls, Scotch)	4
Water (oz)	47.5

BACKGROUND:

As the sun travels in the sky from morning to night, its rays travel the shortest distance to our eyes around noon, and the longest distance in the morning and evening. That "distance" isn't just empty space, though. It's our atmosphere—a protective bubble of gas that surrounds the earth. The longer the distance the rays must travel, the more atmosphere they have to pass through to reach our eyes.

This experiment shows that some colors of light scatter more than others as they travel across distances! Blue scattered so much that after some milk was added to the cup of water, no blue light could pass through. Red, on the other hand, scattered the least, and continued to pass through the water. That's why the sky looks pink and orange at sunset—those reddish colors are the ones that get the least scattered by particles in the air as they travel to your eyes!

If we wanted to make our experiment more like an actual sunset, we would have lengthened the amount of water the light had to pass through instead of adding milk to it. However, that's difficult to do. Instead, we used milk to represent the "dirtiness" of the air. Our atmosphere is made up of gasses like nitrogen, oxygen, and carbon dioxide, but it also contains all kinds of particles like dust, water, and smoke. These particles aren't noticeable at short distances, but have you noticed how mountains in the distance seem blurry? Over long distances, light is scattered by these particles. The more particles there are to scatter the light, the more colorful the sunset looks! (*The Science Book of Color*, Neil Ardley)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. Select the hypothesis:

A. Mirrors reflect objects and bounce light rays.

GOAL: To illustrate light scattering using milk, water, & LEDs as a model of the sky.

WHAT GOES HOME: Nothing

PROCEDURE:

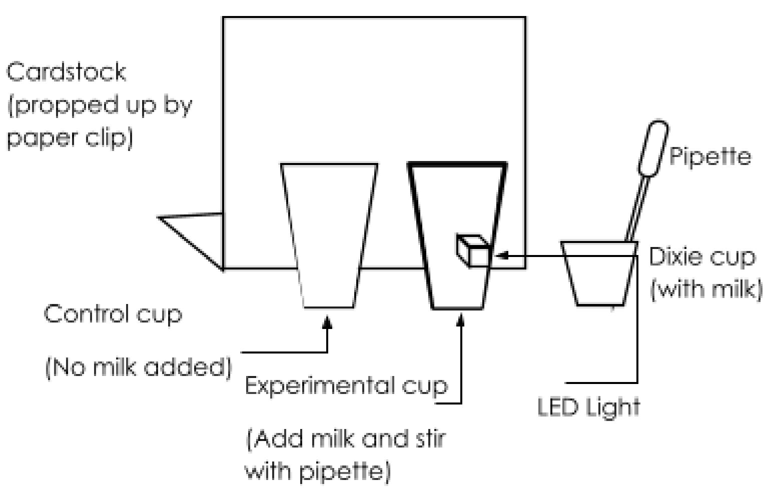
1. **Tell the scientists:** Three Japanese scientists, Isamu Akasaki, Hiroshi Amano, and Shuji Nakamura, recently discovered how to make blue LED lights, just like the ones we use in our experiments. This work was important because LED bulbs couldn't shine pure white before this discovery. Let's be physicists like these professors and explore how light works.
2. Put students in four groups. Give each group:

a. **Two 10oz plastic cups** filled about three-quarters full of water (one labeled "experimental" and the other labeled "control" as prep).
b. **One Dixie cup about half full of milk** (from prep).
c. **One blue LED light, one red LED light, and one white LED light**.
d. **One pipette**.
e. **One cardstock wall** from prep.

Discussion Prompts:

- *What happens when dust or smoke gets in the way of your vision?*
- *How do you think light changes when it's blocked by dust, smoke, or other particles?*
- *Have you ever seen a colorful sunset?*
- *Where do you think those colors come from?*

3. Have students set up their supplies. (Photo 4.7 + Diagram below)
   a. Place the control cup and experimental cup next to each other about 3-6 inches away from the cardstock. Each cup should be filled three-quarters with water. and 3-6 inches away from the front of the propped-up cardstock (students can also use a light-colored wall in place of the cardstock if one is available next to a desk).
   b. The pipette will be used to add milk to the experimental cup from the Dixie cup, so place those next to the experimental cup.
   c. Throughout the experiment, students will shine an LED light through the control and experimental cups (Photo 4.8).



4. Explain to students the importance of having an "experimental" and a "control" cup while they set up their experiment. Scientists use controls so that they have something to compare their experimental subject to. Via comparison, scientists are better able to see how much change has occurred through their experimentation. Without control, it can be hard to tell if and how something has changed.

5. Allow students in each group to choose one of 4 roles: white LED light holder, red LED light holder, blue LED light holder, and milk mixer. Students can also rotate roles throughout the activity.
6. Have the white, red, and blue LED light holders take turns shining their light through the control cup, then through the experimental cup. A good technique is to start with the light nearly touching the water cup and then to slowly move it backwards until the light appears as a focused rectangle on the cardstock (Photo 4.8).
7. Have the milk mixers use the pipette to add 10-15 drops of milk (or one small squirt) to the experimental cup, mix the liquids together, then carefully return the pipette to the Dixie cup.

Discussion Prompts:

- *What do you think happens when clear air becomes cloudy with particles?*
- *Before adding any milk: Does the light pass through the water in both cups and onto the cardstock equally? Will this be true if we add milk to one of the cups?*
- *Do you think each color of light will behave the same way? What are your hypotheses for the white light, red light, and blue light respectively as we add milk?*
- *After the first round of milk-adding: does light from the white LED look the same coming through the control and experimental cups? What about the other colors of LED lights?*

8. Have the white LED light holder shine their light through the experimental cup, then shine the light through the control cup to compare. As more milk is added to the experimental cup, the white light coming through to the cardstock will decrease in brightness and then turn from white to yellow to orange to red.
9. Have the red LED light holder repeat step 7. The red light should remain red but become progressively dimmer as more milk is added to the cup.
10. Have the blue LED light holder repeat step 7. The blue light should also remain blue but dim and then disappear much faster than the red and white lights.
11. Repeat steps 6-9, along with the discussion questions that ask how the light changes.
12. End the experiment when the white light fades to a faint red. Have the students discuss how the observed results compared with what they thought would happen (their hypotheses) and introduce the concept of diffraction (or light scattering).
13. Save the cardstock "walls" for future classes.

ACTIVITY PHOTOS:

4.7 

4.8 

ACTIVITY 5: DAILY DEBRIEF

TIME: 5 Minutes

GOAL: Reflect on what was explored during the activities and relate to students' own lives.

PROCEDURE:

1. Gather students in a circle.
2. Ask questions that facilitate a thoughtful reflection of the day's lessons. Questions may be considered in a Pair & Share model.
3. If you are short on time, have students think about the questions while they are cleaning up from the activities.

Example questions:

- *What happened today?*
- *What was a challenge that you overcame?*
- *What did you learn about color?*

CLEAN UP: Implement a fun, daily clean-up routine so that students practice being "truly helpful" to their AKA Science community.

WHAT TO SAVE: Some items will carry over into future classes and others will require proper disposal. We have created a table to help organize your materials by when they will be used again. If an item has a number in the column marked "move to:", all the items used today should be moved to the new class bag. If marked "send home", the items are to go home with your scientists. "Save for SUN, recycle, or discard" means the items can be kept for use by your site or discarded as needed.

Fun Physics: Color & Light (Grades 3-5)

Class 4: Light Splitting

Supplies	Move to:	Send home	Save for SUN, recycle, or discard
Colored filters, blue		X	
Colored filters, red		X	
Colored filters, yellow		X	
Cups, 10oz			X
Cups, 20oz	Class 7		
Cups, calibrated, 1oz			X
Cups, Dixie			X
Lab notebooks	Class 5		
LED flashlights	Class 5		
LED lights, blue	Class 6		
LED lights, red	Class 8		
LED lights, white	Class 5		
Markers, black washable	Class 6		
Paperclips, jumbo – *cardstock walls, leave assembled if possible*	Class 5		
Pencils	Class 5		
Pipettes			X
Pitcher	Kit box		
Plastic sheeting, black 4x4in squares		X	
Powdered milk (in bag)			X
Prisms, teardrop		X	
Prisms, triangular		X	
Pushpins	Class 8		
Rainbow viewers		X	
Rubber bands, size 16		X	
Scissors (site provides)			X
Spoon			X
Tape, Scotch rolls	Class 5		
Water			X
Worksheets			
Color Wheel			X
Paper, cardstock, white – *cardstock walls, leave assembled if possible*	Class 5		
Paper, construction, black		X	

GRAND TOTAL OF WHAT GOES HOME: Spectroscope, colored filters, acrylic triangular OR crystal teardrop prism (decided among each pair which student takes home which).

CLASS 5: REFRACTION & REFLECTION

Supplies (in class bags)	#
Cardstock walls from Class 4	8
Bowls, large clear plastic – *in kit box*	4
Dowels	4
Lab notebooks	16
LED flashlights	4
LED lights, white	4
Mirror boards	16
Mirrors 2x3in	16
Pencils	16
Play doh, containers	4
Rulers	4
Sticky tack strip	1
Straw pieces	4
Tape, Scotch rolls	4
Water	
Worksheets (in envelope)	**#**
Paper, white	32
Paper, white, 11x17	4

PREP STEPS:

- **Act. 3:** If cardstock walls were not prepared for Class 4, please turn to page 41 and follow the instructions to create 8 cardstock walls.
- **Act. 4a:** Divide sticky tack into 4 pieces.
- **Act. 4b:** Fill each large plastic bowl ¾ full of water.

VOCABULARY:

- **Reflection:** The throwing back by a body or surface of light, heat, or sound without absorbing it.
- **Symmetry:** When something is made up of exactly similar parts facing each other or around an axis.

ACTIVITY 1: PAIR & SHARE

TIME: 5 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16

GOAL: Gauge students' knowledge of today's subject and invite questions

PROCEDURE:

1. Pass out **a notebook and a pencil** to each scientist.
2. Ask a question that relates to today's subject. Have the scientists answer the question by drawing or writing in their notebooks or simply thinking about it.

   Example Questions:
   - *How could you redirect or move a beam of sunlight?*
   - *Can you think of a way that mirrors help us see in places we normally can't?*

3. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

ACTIVITY 2: FUN HOUSE MIRRORS

TIME: 20 Minutes

SOURCE: *49 Easy Science Experiments with Optics by Robert W. Wood, www.exploratorium.edu*

Supplies	#
Mirror Board Sheets	16
Mirrors (2inx3in)	16
Pencils	16
Worksheets	**#**
Paper (8.5inx11in, sheets, white)	32

BACKGROUND:

Normally, light travels in a straight line when it's reflected off a flat mirror. A bent mirror, however, reflects light in a different way than a flat mirror due to its curved shape. There are two types of curved mirrors. Mirrors that bend inwards like a cave (the middle is farther from you when you're looking at it) are called concave mirrors. Mirrors that bulge outwards (the middle is closer to you) are called convex mirrors. Curved mirrors are used for lots of things. Concave mirrors take light rays that are farther apart and focus them on a point in front of the mirror. They can be used to magnify a reflection, like in a makeup compact, or to focus light on an object (and start a fire!). Convex mirrors take light rays that are closer together and spread them out. They are often used in hallways because their shape allows you to see around corners and avoid walking into someone. You might notice them in convenience stores or on the corners of driveways. (bit.ly/3ORPWbT)

GOAL: To study how changing the shape of a mirror changes its reflective properties using flexible mirror boards.

WHAT GOES HOME: Secret messages and drawings

PROCEDURE:

1. Give each student a flexible **mirror board** sheet.
2. Have students explore by bending the mirrors and making observations.
3. Have students hold the mirror by the edges without bending it. Students should close one eye, or cover one eye with their hand, and look at their reflections in the mirror.

   Discussion Prompts:

   - *Can you change the way you look in this mirror by bending or moving it? Can you make yourself look narrower or wider? Can you flip your image upside-down? What did you do to the mirror to make that happen?*
   - *If you bend the mirror top to bottom so that it bulges towards you, do you look smaller or larger? What about if you bend it in the opposite direction?*
   - *What would happen if you wrote something and then looked at it in a mirror? Can you bend the mirror so that the text flips and you can read it?*

4. Then, have students gently squeeze the left and right edges of the mirror together so the center of the mirror bulges away from them, leaving the left and right side closer to them. This should create the illusion of the student's face splitting in two and then coming back together (Photo 5.1).
5. Pair students. Give each student **a sheet of paper and a pencil**.
6. Have students write their name on the paper.
7. Have students take turns looking at their writing in the mirror. One student should hold the mirror while the other looks at their writing in the mirror. Students should experiment with bending the mirror to change the orientation of the reflected text.
8. Have each student try to write their name backwards so that it appears forwards when reflected in a flat mirror.
9. Give each student a **2inx3in mirror**.

10. Have students fold their paper hamburger-style (bringing the two short ends together) and open it back up.
11. Have students write their name HEAVILY with the pencil on the inside of the folded sheet.
12. Have students refold the paper and rub firmly on the blank, outer part of the sheet to transfer the pencil image inside the folded paper. Unfold the paper (Photo 5.2).
13. Have students use their pencil to write over and darken the transferred design.
14. Have students hold their 2inx3in mirror upright with one edge on the paper, above the transferred image. The transfer image should appear "normal", or right-side-up in the mirror (Photo 5.3).
15. Have students write the word "TOT" in capital letters on their paper.
16. Have students hold their 2inx3in mirror upright with one edge on the paper, along one side of the word "TOT."
17. Have students look at the word in the mirror. They should notice that the word looks the same.

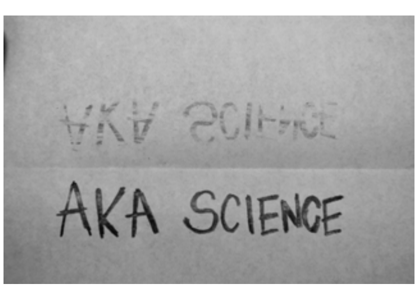
Discussion Prompts:

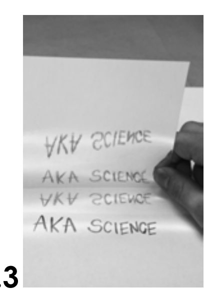
- *Can you think of other letters or numbers that are symmetrical?*
- *How could you use what you know about mirrors to write a secret message?*

18. Have students draw a vertical line down the center of the letters "T" and "O." Students should notice that the shapes of the letters are the same on either side of the vertical line, indicating that the word TOT is symmetrical.
19. Allow students some time to explore and experiment with other shapes, letters, numbers, or words.
20. Have students write a short sentence on one side of the paper. Make sure students don't show each other their messages, as they will pass them to each other for decoding later.
21. Have students look at their writing in the mirror. It should appear reversed.
22. Give each student another sheet of paper.
23. Have students copy the reversed writing they see onto the second sheet of paper.
24. Pair students.
25. Have pairs exchange messages and try to decipher each other's message, first without and then with mirrors.

ACTIVITY PHOTOS:

5.1 

5.2 

5.3 

ACTIVITY 3: LIGHT MAZE

TIME: 20 Minutes

SOURCE: *Elementary Exploration: Seeing the Light* by The NEED Project

Supplies	#
Cardstock walls	8
LED Flashlight (3-bulb)	4
LED Lights (white)	4
Mirrors (2inx3in)	16
Pencils	16
Play-Doh (containers)	4
Tape (rolls, Scotch)	4
Worksheets	
Paper (11inx17in, sheets, white)	4

BACKGROUND:

It's not easy to bounce light where you want it to go, but light reflects off mirrors in a very specific way. The angle from which light hits a mirror is identical to the angle from which it reflects and leaves the mirror!

Have you ever wondered how laser grids like the ones in action movies are made? Some of them use the reflective properties of mirrors, just like the maze you created. A single laser beam can be reflected over and over again to create a laser grid. The last mirror reflects the light to a sensor. When any part of the path of the laser light is broken, the sensor doesn't see the light anymore and sets off the alarm! Just like your maze, the grid uses mirrors to create an unbroken path of light. Unfortunately, in real life, laser alarm systems use infrared lasers, so you wouldn't be able to see the lasers and dodge them! (bit.ly/3KxFP9B)

GOAL: To use knowledge of reflections to position mirrors to see around obstacles.

WHAT GOES HOME: Nothing

PROCEDURE:

1. Put students in groups of 3-4.
2. Give each group **four 2inx3in mirrors, four pencils, one 3-bulb LED flashlight, one single-bulb white LED light, one piece of 11inx17in paper, one container of Play-Doh, and two cardstock walls** (from Class 4).
3. Have students place the 11inx17in paper on the table with one of the short edges closest to them. Set up the two cardstock walls on top of the paper with one about a foot behind the

other. The students should use the 11inx17in paper as a guide to line the cardstock walls up in the same direction.

4. Have students set their 3-bulb LED flashlight about six inches in front of the cardstock wall that's closest to them, pointing it at the wall. Tell students their goal is to reflect their light around the closer wall so that it shines on the center of the back wall *without changing the position of the LED light itself*.

Discussion Prompts:

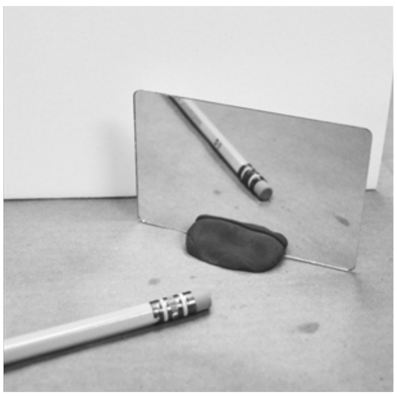
- *Last activity, we learned that the way light reflects off mirrors depends on the angle and shape of the mirrors. How could we use this to solve this puzzle?*

5. Prepare students so they have tools for the challenge:
    a. Have students split their Play-Doh into four equal balls. Each student in a group should take one ball and gently lower the long edge of one mirror into the Play-Doh until it almost touches the table. Students can then push the ball down lightly to create a stable base. The mirror should be able to stand up on its own, completely perpendicular to the table. Students should also be able to pick up the mirror with the Play-Doh base and rotate or move it as needed (Photo 5.4).
    b. Show students how to predict the path of light by shining one LED light on a mirror and placing a pencil along the line of the beam's reflection. They can use a cardstock wall as a target. If students line up pencils to point in the direction they want the light to go, they'll know where to set up their mirrors (Photo 5.4).
    c. Show students that when trying to line up a mirror, they can flip their target mirror around to make sure that the reflected beam of light is hitting it. When it's lined up, they can flip the target mirror back and adjust it to hit the next target mirror.
    d. Tell students that they will only use one LED light to prove that their setup works, but you've given them a second LED light so they can work on multiple parts of their setup at the same time.

6. Reiterate to students that the only rules are they cannot move either the source light or cardstock wall, and the beam of light must hit the back cardstock wall. (Note: one student may need to hold the LED light steady, slightly above the surface of the table, so the beam of light fully hits the mirror.) Encourage students to work cooperatively in teams, honoring the input of all teammates and ensuring that all students have a hand in the solution (Photo 5.5).
7. Turn off the lights in the room, if possible.
8. Give students at least 10 minutes to work on the challenge.
9. After 10 minutes, you may want to give hints or help some students overcome obstacles you see.
10. Allow students the option of sharing their solutions to the challenge. If students need additional help. You can share an example solution, but keep in mind there are lots of ways to solve the puzzle (Photo 5.6).

11. If a group finishes early, you can increase the challenge difficulty by introducing more obstacles.
12. Emphasize to students that completing the challenge is great, but even if they couldn't get the light all the way to the back wall, they still learned a lot by working through the challenge as a team!
13. Keep the cardstock "walls" for use in other classes.

ACTIVITY PHOTOS:

5.4


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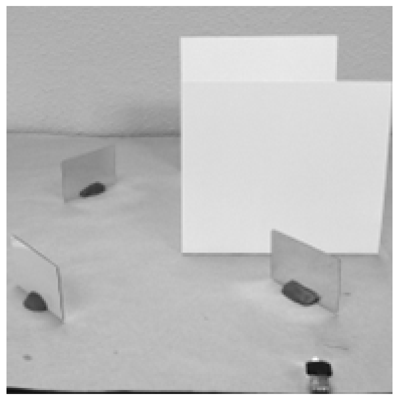

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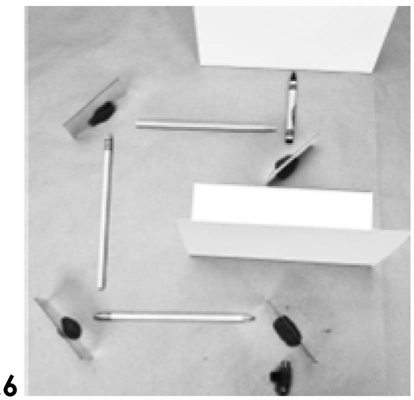


ACTIVITY 4: SPEAR FISHING

TIME: 10 Minutes

SOURCE: Eagle Spirit Science Futures

Supplies	#
Bowls, large clear plastic	4
Dowels	4
Play doh (containers)	4
Rulers	4
Sticky tack strips	1
Straw pieces	4
Tape, Scotch rolls	1
Water	

BACKGROUND:

When you see things around you, light usually travels through the air to your eyes, which receive the light. However, light passes through other things as well: solids like glass and clear plastic, and liquids like water and oil. Each different substance affects the light passing through it differently. Light passes through most substances slower than it does through air. That means that it is bent more. The scientific word for bending light is refraction! When light rays bend, or refract, when they go from air to water, objects appear magnified and seem as though they are in different spots. Our eyes get tricked because we think the light rays should continue on the same straight line as when it travels through air. People who use fishing spears have to adjust for the fact that a fish's location underwater is slightly different than it appears. By learning how to adjust for the refraction of light through water, spear fishers can increase the likelihood of catching fish on the first try. (bit.ly/47Vd3tZ)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. What happens to light when it passes through things like water or binoculars?

A. The light bends

GOAL: To explore light refraction through water by simulating spear fishing.

WHAT GOES HOME: Nothing

PROCEDURE:

1. **Tell students:** Spearfishing has been used by many Indigenous groups throughout the world, and people like Native Hawaiian Matt Sproat are carrying on the tradition. To spear a fish, the person fishing must understand light refraction and the way it changes how far away a fish looks when underwater. Let's see if we can use physics like Mr. Sproat to catch fish!
2. Divide scientists into four groups. Give each group **¼ piece of sticky tack, one straw piece, one dowel, one container of playdoh, one ruler, and one bowl** filled ¾ full of water (from prep).

   Discussion Prompts:

   - *What usually separates us from anything we're looking at? (air)*
   - *Do you think things would look different if light traveled through something other than air?*
   - *What do you think the ruler will look like if we put it in the cup of water?*

3. Have each group place their ruler straight down into the bowl of water and observe how the ruler looks. This works best if one scientist holds the ruler while the rest of the group looks at the bowl from the side. Roles can be switched to allow each scientist to observe the ruler (Photo 5.7)

Discussion Prompts:

- *What does the ruler look like when part of it is in the water?*
- *Why do you think this happens?*
- *Do you think this will make it easier or harder to touch something under the water?*

4. Have groups divide their pieces of playdoh into 4 smaller pieces. Each scientist will use one piece to make a small fish.
5. Tell the groups to select one of the fish to place in the bottom of the bowl of water. They will need to press down on the fish to help it stick (Photo 5.8).
6. Have each group roll the piece of sticky tack into a ball and mount it on the side of the bowl. Once the sticky tack is in place, they can press the straw piece onto the sticky tack. If needed, secure the straw with tape (Photo 5.9).

Discussion Prompts:

- *Why is it important to catch the fish on the first try?*
- *If you needed to catch a fish with a spear, how would you position your spear, so you don't miss?*

7. As a team, each group should position their straw so that it looks like it is pointing directly at the fish in the water below (Photo 5.9).
8. Ask the groups to make a hypothesis about whether they will be able to touch the fish underwater with their "spears".
9. Have one scientist in each group insert the dowel into the straw without moving the straw position. This scientist should then slowly slide the dowel into the water while observing the fish from above. Once the dowel looks like it should be touching the top of the fish, have the groups observe from the side of the bowl how far away the dowel is (Photos 5.10 - 5.11).

Discussion Prompts:

- *How close were you to touching the fish?*
- *How could we change the angle of the straw to come closer to the fish?*

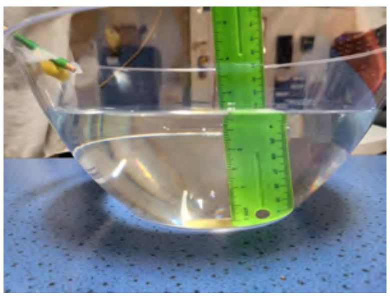
10. Use the ruler to measure the distance from the fish to the top of the water. Then measure from the dowel to the top of the water. Subtract the second measurement from the first measurement and write down the difference in lab notebooks (Photo 5.12).
11. Have groups adjust the straw to point just below the fish and try again. Measurements can be repeated by each group member.
12. Have your other scientists test the spear fishing, allowing them to switch the play doh fish to their own if they wish.

Discussion Prompts:

- *How difficult was it to touch the fish? Were you able to make it easier by adjusting the straw?*
- *Would more or less water change how hard it was to touch the fish?*
- *Why is this important for spearfishing?*

13. Clean up all materials, discarding wet playdoh, straw pieces, and sticky tack.

ACTIVITY PHOTOS: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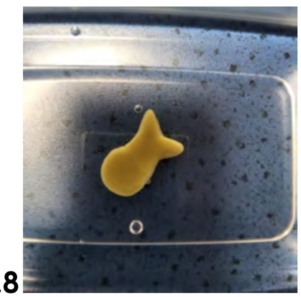
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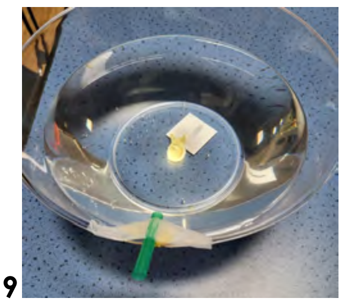
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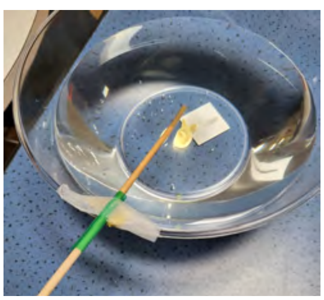
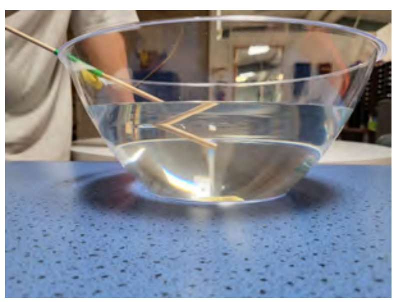

5.10


5.11


5.12

ACTIVITY 5: DAILY DEBRIEF

TIME: 5 Minutes

GOAL: Reflect on what was explored during the activities and relate to students' own lives.

PROCEDURE:

1. Gather students in a circle.
2. Ask questions that facilitate a thoughtful reflection of the day's lessons. Questions may be considered in a Pair & Share model.
3. If you are short on time, have students think about the questions while they are cleaning up from the activities.

Example questions:

- *What happened today?*
- *What was a challenge that you overcame?*
- *What would we do if we had more time?*
- *Do mirrors work without light?*

CLEAN UP: Implement a fun, daily clean-up routine so that students practice being "truly helpful" to their AKA Science community.

WHAT TO SAVE: Some items will carry over into future classes and others will require proper disposal. We have created a table to help organize your materials by when they will be used again. If an item has a number in the column marked "move to:", all the items used today should be moved to the new class bag. If marked "send home", the items are to go home with your scientists. "Save for SUN, recycle, or discard" means the items can be kept for use by your site or discarded as needed.

Supplies	Move to:	Send home	Save for SUN, recycle, or discard
Cardstock walls from Class 4			X
Bowls, large clear plastic			X
Dowels			X
Lab notebooks	Class 6		
LED flashlights	Class 8		
LED lights, white	Class 7		
Mirror boards	Class 6		
Mirrors 2x3in	Class 6		
Pencils	Class 6		
Play doh, containers			X
Rulers			X
Sticky tack strip			X
Straw pieces			X
Tape, Scotch rolls	Class 6		
Water			X
Worksheets			
Paper, white		X	
Paper, white, 11x17			X

GRAND TOTAL OF WHAT GOES HOME: Secret messages and other drawings from Fun House Mirrors.

CLASS 6: MIRROR, MIRROR, ON THE WALL

Supplies (in class bags)	#
Beads, multicolored tri	128
Cardstock strips	16
Crayons, box	4
Cups, 1oz	16
Lab notebooks	16
LED lights, blue	4
LED lights, green	4
Lids, 1oz	16
Markers, black washable	2
Mirror boards	16
Mirrors, 2x3in	16
Mirrors, round	16
Paperclips, jumbo	8
Pencils	16
Scissors (site provides)	16
Tape, Scotch rolls	4
Worksheets (in envelope)	**#**
Periscope pattern	16

PREP STEPS:

- **Act. 4a:** Place 8 beads in each of the 16 1oz cups. Place a lid on each cup.
- **Act. 4b (optional):** Draw lines on the backs of the 16 mirror boards with the black markers to help students fold them into thirds.

VOCABULARY:

- **Periscope:** an instrument for observation over, around, or through an object or obstacle.

ACTIVITY 1: PAIR & SHARE

TIME: 5 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16

GOAL: Gauge students' knowledge of today's subject and invite questions

PROCEDURE:

1. Pass out **a notebook and a pencil** to each scientist.
2. Ask a question that relates to today's subject. Have the scientists answer the question by drawing or writing in their notebooks or simply thinking about it.

   Example Questions:
   - *What do we use mirrors for?*
   - *Where do we find mirrors in everyday life?*
   - *How are mirrors different or similar to windows?*
   - *How could you use a mirror to light up a dark room?*

3. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

ACTIVITY 2: MULTIPLE MIRRORS

TIME: 10 Minutes

SOURCE: *Amazing Experiments in Sound and Light* by Michael A. DiSpezio

Supplies	#
Mirrors (2inx3in)	16
Paper Clips (jumbo)	8
Tape (rolls, Scotch)	4

BACKGROUND:

When you look in one mirror, you see one reflection. When you look in two mirrors, you see more than two. When you put three mirrors together, you see infinite reflections! How is that possible? Let's remember what reflections are: rays of light bouncing perfectly off a surface and into your eyes. If the reflected rays of light hit another reflection before hitting your eyes, you'll see two images! But, keep in mind that the rays of light from one mirror hit the other, so with two mirrors, you can see four reflections or more by changing the angle of the mirrors. The angle of the mirrors changes how many times the rays of light bounce between the mirrors before reaching your eyes. More bouncing = more reflections!

When you add the third mirror, you trap all the bouncing light rays in that chamber. All the light bounces between the three mirrors and forms an infinite chamber of reflections! If you've ever stepped into a hall of mirrors, now you know how it makes you look like you're surrounded by yourself. A hall of mirrors is just a trap for rays of light! (bit.ly/447IXQP)

GOAL: To change mirror angles to create an endless reflection of a paper clip.

WHAT GOES HOME: Nothing

PROCEDURE:

1. **Tell scientists:** Almost one thousand years ago, Muslim scientist Al-Hasan Ibn Al-Haytham wrote many books explaining the ways light and sight work together. Some of these books also explained how mirrors can be shaped to change and reflect images and light. Let's examine how mirrors work, like Ibn Al-Haytham did.
2. Give each scientist a **2inx3in mirror** and have them look at themselves in the mirror.
3. Give each student a **small piece of Scotch tape** and have them place the piece of tape on one of their cheeks.
4. Have students note which side of their face (right or left) the tape is on. Then have them look in the mirror. In their reflection, each student's tape/ tongue will be on the same side as where they can feel it.

   Discussion Prompts:

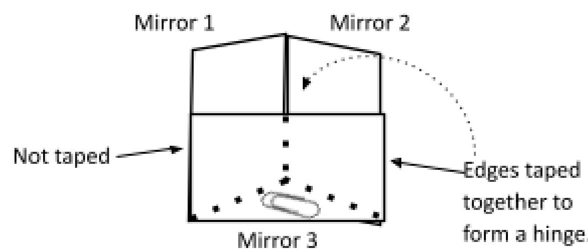
   - *Why do you see yourself when you look in a mirror?*
   - *Do other people see you the same way you see yourself in a mirror? What is the same and what is different?*
   - *How could you use mirrors to see your face the same way other people see it?*

5. Pair students. Ask students where they see their partner's tape, on the left or the right? (If the tape is on a student's left cheek, the other student will see that as their right cheek.)
6. Have students take turns holding two mirrors together at an angle (about 45°) so their reflected image bounces between the two mirrors. If they position the mirrors correctly, they will see themselves as others see them, i.e., reversed (Photo 6.1).
7. Explain that mirror images are right/left reversed. So, we actually see ourselves differently in the mirror than how other people see us.
8. Divide students into groups of three and give each group a **jumbo paper clip**. Make Scotch **tape** available to share.
9. Have groups place their paperclips on the table.

Discussion Prompts:

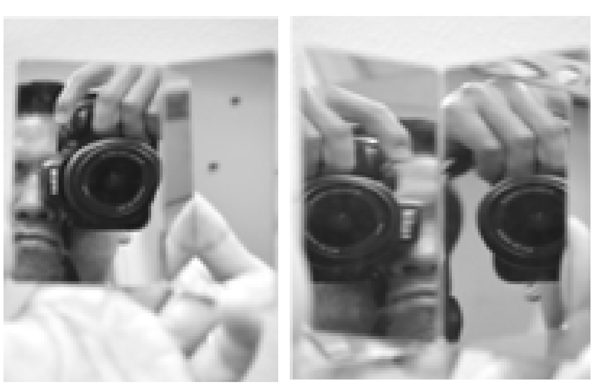
- *Have you ever looked into the mirrors in a dressing room and seen several images of yourself? How do you think it works?*
- *How could you multiply the number of paper clips you see in the mirror(s)?*

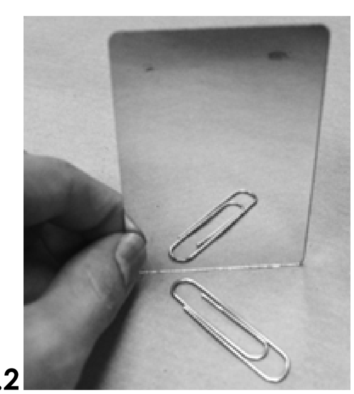
10. Have one student in the group hold a mirror facing the paper clip with the short edge on the table (Photo 6.2).
11. Have another group member hold a second mirror next to the first mirror, oriented the same way so that one long edge of each mirror touches the other. The mirrors should be at slightly less than a right angle around the paper clip, i.e., slightly smaller than a right angle.
12. Have the third student place a piece of tape over the line where two mirror edges meet. This should create a hinge that allows students to change the angle of the mirrors while still keeping the mirrors together.
13. Have students count the number of paper clips they see reflected in the two mirrors.
14. Have the third student stand their mirror up differently than the first two, laying the long edge on the table instead of the short edge. The three mirrors should form a closed triangle around the paper clip.
15. Have another student tape over the edge where the 2nd and 3rd mirrors meet. For the three total mirrors, there should be two pieces of tape and one free space. This will allow students to adjust the size of the triangle and the angles of the mirrors.



16. Have students take turns looking over the top of the third (horizontal) mirror to observe the reflections of the paper clip and discuss what they see (Photo 6.3).
17. Allow groups to experiment with changing the size and angles of the mirror triangle and observe how that affects the number of paper clips and their closeness to each other.

ACTIVITY PHOTOS:

6.1 

6.2 

6.3 

ACTIVITY 3: PERISCOPE

TIME: 20 Minutes

SOURCE: *Science Works-65 Experiments that Introduce the Fun and Wonder of Science* from the Ontario Science Center

Supplies	#
Cardstock Strips (2inx4.25in)	16
Crayons (box)	1
LED Lights (blue)	4
LED Lights (green)	4
Markers (black, washable)	2
Mirrors (2inx3in)	16
Mirrors (round, 1.75in)	16
Scissors (site provides)	16
Tape (rolls, Scotch)	4
Worksheets	**#**
Periscope Pattern (cardstock)	16

BACKGROUND:

Light travels in a straight line, but as you learned by making your light maze, it can also be reflected. This is very important in submarines. It takes a lot of power to get a submarine up to the surface of the water. But with mirrors, you don't have to raise the whole submarine just to see above the water. A periscope is a tube that runs from the inside of a submarine to above the surface of the water. By placing mirrors in a tube so they are angled towards each other, light is reflected from above the water, down the tube, and into your eye so you can see what's happening above the surface.

What if you're on land and want to see underwater without getting wet? You can use a periscope then, too! You can use the periscope in the same way, but this time you stay above the water and put the periscope beneath the surface of the water. (bit.ly/3qtBQEl)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. Select the hypothesis (Circle one):

A. Mirrors reflect objects and bounce light rays.

GOAL: To reinforce the idea that mirrors can be positioned to see around obstacles.

WHAT GOES HOME: Periscope

PROCEDURE:

1. Give each student a **round mirror**. Have students hold the mirror up near their eyes and allow them to explore what they can see around them by changing the angle of the mirror.

   Discussion Prompts:

   - *How could you use a mirror to look at something in the room behind you without turning your head?*
   - *How could a spy use a mirror to watch a target without being spotted?*

2. Give each student **a Periscope Pattern worksheet and a pair of scissors**. Make **crayons, markers & tape** available.
3. If time allows, students can decorate the printed side of their Periscope Pattern with crayons and markers. It's easiest to do the decorating first.
4. Have students:
   a. Cut the long, solid black line to remove the title section of the worksheet.
   b. Fold the worksheet on each of the four dashed lines. (It's important to fold slowly and carefully: there are four pre-cut slits in the worksheet, and careful folding will make sure they don't get torn. As you fold, you'll be making a rectangular tube with the printing on the outside.)
   c. Cut out the two windows. Each window should be cut from the edge of the page, even though the image doesn't go all the way to the edge.
   d. Bring the two edges of the paper together to form a closed rectangular tube. Tuck the short flap underneath the other edge of the tube and tape it in place. (It helps to tape the top, bottom and middle of the tube.)
5. Give each student a **cardstock strip**.
6. Have students:
   a. Carefully slide the cardstock strip through one set of slits.
   b. Make a loop of tape and stick it on the back of the round mirror.
   c. Press the back of the round mirror onto the cardstock strip, so that the reflective (shiny) part of the mirror is visible through the window opening (Photo 6.4).
7. Allow students to experiment with their spy tools. They can point the open end of their tube at an object they want to see, and the object will be visible as a reflection in the mirror. If it's safe to do so, allow students to walk around and explore. Encourage them to rotate their tubes and view different objects.
8. After students have explored, have them return to their seats.

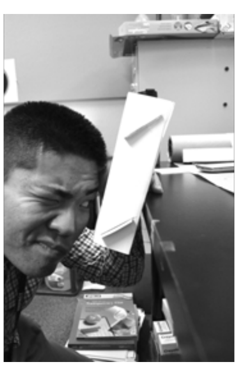
Discussion Prompts:

- *How can sailors in submarines see what's on the surface of the water while they are underwater?*
- *How could we alter our spy tool to solve the problem?*
- *When might a periscope be useful outside of a submarine?*
- *What could make your periscope more useful for an undercover spy?*

9. Give each student a **2inx3in rectangular mirror**. Ask the scientists to hypothesize about how this mirror can be used in the periscope.
10. Have students slide the mirror *gently* through the other set of slits with the reflective side facing upwards. The reflective side of the mirror should be visible through the top window opening. The spy tool has now become a periscope.
11. Pair students and give each pair a **green or blue LED light**.
12. Have one student in each pair hold their periscope vertically with the round mirror at the bottom.
13. Have that student shine an LED light at the round mirror while the other student holds their hand in front of the rectangular mirror and discuss what happens.
14. Allow time for students to explore. Here are some other fun ways students can test their periscope:
    a. One student can wiggle their fingers or give hand signals in front of the round mirror while the other student watches in the rectangular mirror.
    b. One student can crouch down in front of a desk so that they can only see what's under the desk if they look straight ahead. By holding the periscope vertically in front of them with the top sticking up over the desk, and looking at the round mirror, they should be able to see what's on top of the desk, just like in a submarine! Their partner can act out a scene above the desk, draw them a picture, or write a secret message (Photo 6.5)!
    c. Students can hold their periscope sideways and try to see around corners or doorways. If a corner or doorway isn't available, students can use a table or chair as an obstacle to peer around.

ACTIVITY PHOTOS:


6.4


6.5

ACTIVITY 4: KALEIDOSCOPE

TIME: 20 Minutes

SOURCE: *Science for Fun Experiments* by Gary Gibson

Supplies	#
Beads (multi-colored, transparent)	128
Crayons (box)	1
Cups (1oz)	16
Lids (1oz)	16
Markers (black, washable)	2
Mirror Board Sheets	16
Tape (rolls, Scotch)	4

BACKGROUND:

A kaleidoscope is a toy made from three mirrors set in a triangle. There are small objects inside the kaleidoscope that move around as you twist the tube. The different ways the objects fall reflect differently, making lots of pretty pictures. Kaleidoscopes can be simple, like three mirrors in a cardboard tube, or fancy - some are decorated with gold and jewels and have sold for thousands of dollars! (bit.ly/47nIvRj)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. Select the hypothesis (Circle one):

A. Mirrors reflect objects and bounce light rays.

GOAL: To apply the concept of mirror angles to create a simple kaleidoscope.

WHAT GOES HOME: Kaleidoscope

PROCEDURE:

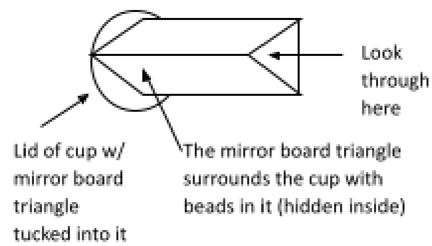
1. Give each scientist **a mirror board and a lidded 1oz cup containing 8 beads** (from prep). Make **crayons, markers, and tape** available.

   Discussion Prompts:

   - *We just learned how mirrors placed together can multiply images. Can you think of any toys that do the same thing?*

- *What is a kaleidoscope? How might it work?*
- *Would a kaleidoscope work in total darkness? What is your* *<u>hypothesis</u>*?

2. If time allows, students can decorate the back of their mirror boards (the non-reflective side) with crayons and markers. It's easiest to do the decorating first.
3. <u>Have students</u>:
   a. Fold the mirror board into equal thirds lengthwise, with the reflective side in.
   b. Tape the mirror board closed along the edge so it forms a triangular tube (Photo 6.6).
   c. Turn the 1oz cup with beads upside down so that the lid is on the bottom.
   d. Fit the triangular mirror board tube around the base of the cup, with the edge inside the lid. It's okay if the shape of the tube gets slightly rounded (Photo 6.7).
   e. Tape the edge of the lid around the triangular tube to hold it in place (but don't cover the part where light will come through) (Photo 6.8).

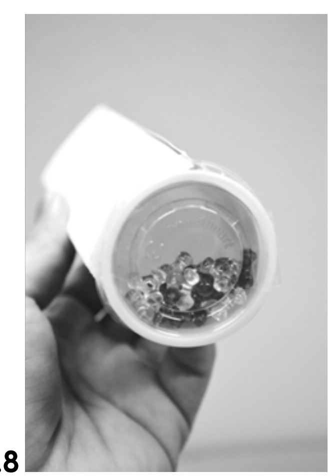


4. Have students hold the tube pointed straight up (so that the cup of beads is at the top) and look through the opening at the bottom. Students can rotate the tube in their hand so that the beads move around. Allow students time to experiment with their kaleidoscopes.
5. Try the kaleidoscopes with the lights off. Do they work? Were your hypotheses correct?

<u>ACTIVITY PHOTOS:</u>


6.6


6.7


6.8

ACTIVITY 5: DAILY DEBRIEF

TIME: 5 Minutes

GOAL: Reflect on what was explored during the activities and relate to students' own lives.

PROCEDURE:

1. Gather students in a circle.
2. Ask questions that facilitate a thoughtful reflection of the day's lessons. Questions may be considered in a Pair & Share model.
3. If you are short on time, have students think about the questions while they are cleaning up from the activities.

Example questions:

- *What happened today?*
- *How are mirrors useful?*
- *What would we do if we had more time?*
- *How does what we learned today apply to your personal life?*

CLEAN UP: Implement a fun, daily clean-up routine so that students practice being "truly helpful" to their AKA Science community.

WHAT TO SAVE: Some items will carry over into future classes and others will require proper disposal. We have created a table to help organize your materials by when they will be used again. If an item has a number in the column marked "move to:", all the items used today should be moved to the new class bag. If marked "send home", the items are to go home with your scientists. "Save for SUN, recycle, or discard" means the items can be kept for use by your site or discarded as needed.

Supplies	Move to:	Send home	Save for SUN, recycle, or discard
Beads, multicolored tri		X	
Cardstock strips		X	
Crayons, box			X
Cups, 1oz			X
Lab notebooks	Class 7		
LED lights, blue	Class 7		
LED lights, green	Class 7		
Lids, 1oz		X	
Markers, black washable			X
Mirror boards		X	
Mirrors, 2x3in		X	
Mirrors, round		X	
Paperclips, jumbo			X
Pencils	Class 7		
Scissors (site provides)			X
Tape, Scotch rolls	Class 7		
Worksheets			
Periscope pattern		X	

GRAND TOTAL OF WHAT GOES HOME: Periscope, kaleidoscope.

CLASS 7: CURIOUS COLORS

Supplies (in class bags)	**#**
Beads, UV color changing	32
Cups, 9oz	4
Cups, 20oz	1
Highlighters, yellow	4
Lab Notebooks	16
LED lights, blue	4
LED lights, green	4
LED lights, white	4
Markers, yellow	1
Newspaper – *in kit box*	1
Paper towels, roll – *in kit box*	1
Pencils	16
Pipe cleaners	16
Polarized filters, 1.5x2.5in	16
Tape, Scotch rolls	4
Water	
Worksheets (in envelope)	**#**
Electromagnetic Spectrum	1
Glow paper, 1/2 sheets	4
Paper, white	4
Post Survey Answer Sheet	1
Post Surveys	16

PREP STEPS:

- **Act. 4a:** Use the yellow marker to create a solid rectangle (roughly 2x3in) on one half of each of the four white sheets of paper (Photo 7.9 in Activity 4).
- **Act. 4b:** Fill each of the four 9oz cups about ¾ full of water.

VOCABULARY:

- **Electromagnetic spectrum:** Describes all of the kinds of light, including those the human eye cannot see.
- **Fluorescence:** The ability of certain chemicals to give off visible light after absorbing radiation which is not normally visible.
- **Phosphorescence:** Light emitted by a substance without combustion or perceptible heat.

- **Polarized film:** An optical filter that lets light waves of a specific polarization pass through while blocking light waves of other polarizations.
- **Ultraviolet:** Light that has a wavelength shorter than that of the violet end of the visible spectrum but longer than that of X-rays. This light generally is responsible for sunburns on skin.

ACTIVITY 1: PAIR & SHARE

TIME: 10 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16

GOAL: Gauge students' knowledge of today's subject and invite questions

PROCEDURE:

1. Pass out **a notebook and a pencil** to each scientist.
2. Ask a question that relates to today's subject. Have the scientists answer the question by drawing or writing in their notebooks or simply thinking about it.

   Example Questions:
   - *What is your favorite color and why?*
   - *What are the primary colors?*
   - *How do objects glow?*

3. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.

*****Make sure to leave enough time at the end of class for students to take the Post-Surveys today! These surveys are required for all participants.*****

*****Give Post-Surveys to your Manager at the end of the day!*****

ACTIVITY 2: POLARIZED LENSES

TIME: 10 Minutes

SOURCE: bit.ly/3DU5i9B

Supplies	#
Polarized Filters (1.5inx2.5in)	16
Scissors (site provides)	16
Tape (rolls, Scotch)	4

BACKGROUND:

Polarized lenses are made of a special material that absorbs and emits light. However, there's an important difference between the light it absorbs from one side and releases from the other! A wave of light actually has a shape. That shape is somewhere between straight up and down and side to side. If you think about a wiggly spaghetti suspended in the air, think about all the different ways you could rotate it. Polarized lenses block about half the light passing through them—either they block the up-and-down waves or the side-to-side waves.

When you look through just one polarized lens, it blocks about half of the waves coming through. You can still see the other half of the light. However, if you cross two polarized lenses, you block both up-and-down and side-to-side waves, so nothing reaches your eyes! That's why the filters look black when you cross two of them at a right angle. (bit.ly/3DU5i9B)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. Select the hypothesis (Circle one):

A. Mirrors reflect objects and bounce light rays.

GOAL: To learn how polarized filters affect light.

WHAT GOES HOME: Polarized filters (after using in next activity)

PROCEDURE:

1. Give each scientist one **polarized filter**.
2. Have students hold the filters up to their eyes and look around the room. The filters have sharp edges, so warn students not to hold them too close to their eyes. If they need to smooth an edge, they can trim with **scissors** or cover with a small piece of **tape**. Encourage the students to discuss what they see.

Discussion Prompts:

- *Does anything look different through the lens?*
- *What do you think a polarized lens does?*

3. Pair students, and have the pairs face each other.
4. Have students hold their filter about an inch from one eye. They should hold it horizontally (the long edges should be on the top and bottom and the short edges should be on the sides). Students should be able to see their partner's eyes clearly (Photo 7.1).
5. Have students close the eye that's not covered by the filter, either by shutting it or covering it with their hand.
6. Have one student in each pair rotate their filter 90° so that it is vertical, and have students discuss what they see (Photo 7.2).
7. Have the second scientist rotate their filter so that it is vertical like their partner's and discuss what they see.

Discussion Prompts:

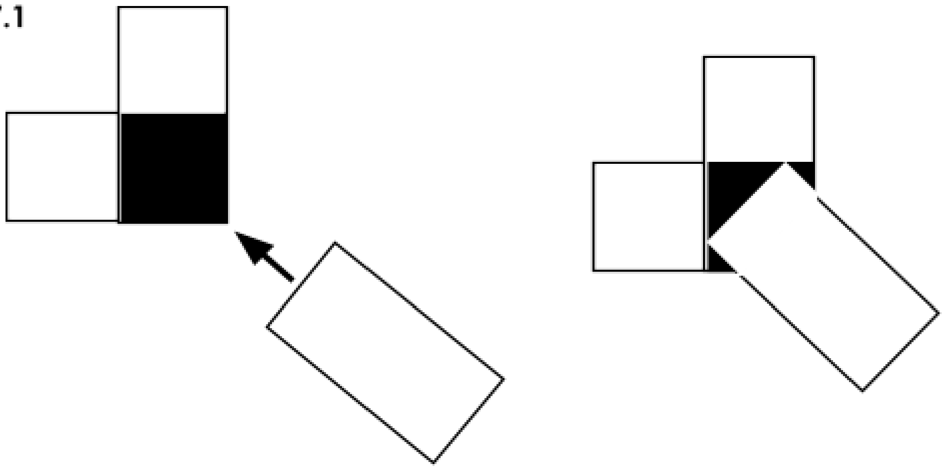
- *What do you think would happen if we put something between two perpendicular polarized lenses?*
- *What do you think you would see with the addition of the third filter? What is your hypothesis?*

8. Have students reset their filters to the horizontal first position (long edges on top and bottom) and switch who rotates their filters first, repeating steps 5 and 6.
9. Explain that polarized lenses block out half of all light on their own. The light blocked out is light coming to the lens from a certain direction (either up/down or sideways). When two polarized filters are put together perpendicularly, each filter blocks out one of the two directions of light, thus blocking all light.
10. In pairs, allow students to cross their filters and rotate them into various positions (Photos 7.3).
11. Challenge students to find positions that create black, clear, and in between.
12. Put students in groups of 3.
13. Have two students place their filters at right angles to each other.
14. Have the third student place their filter diagonally *in between* the other two students' filters (Diagram 7.1 and Photo 7.4).

Discussion Prompts:

- *Why did you choose this design?*
- *Were you able to stick to your plan completely? Why or why not?*

7.1



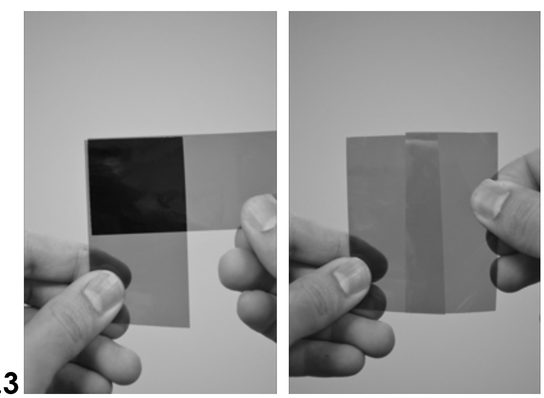
The figure on the left shows the crossed polarized filters, which create black. The figure on the right shows that when a third polarized filter is added at a diagonal *in between* the crossed filters, the black square becomes somewhat clear.

15. Have everyone hold on to their filters for the next activity.

ACTIVITY PHOTOS:

7.1


7.2


7.3


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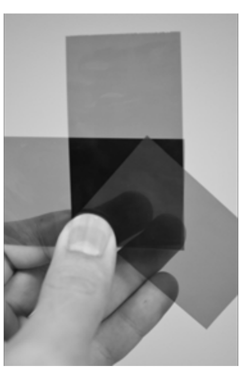


ACTIVITY 3: COLOR-CHANGING BEADS

TIME: 10 Minutes

SOURCE: stanford.io/3wAzkw1

Supplies	#
Beads (UV, color-changing)	32
Pipe Cleaners	16
Polarized Filters (1.5inx2.5in)	16
Worksheets	**#**
Electromagnetic Spectrum	1

BACKGROUND:

Visible light is one part of an electromagnetic spectrum, but many wavelengths of light are invisible to the human eye! Along with visible light, invisible light such as infrared, ultraviolet, X-rays, and radio waves are all forms of radiation, which means they carry energy in waves. The length of each wave and the speed at which it travels determines which form it takes. Ultraviolet radiation is just one of the many types of radiation released by the sun! Most of the other types are absorbed by the atmosphere before they reach us on Earth. Ultraviolet radiation can reach us through the atmosphere, even when it's cloudy! UV radiation can damage your skin. Staying in the sun for too long can give you a sunburn—that's what happens when your skin absorbs too much UV radiation too quickly! Sunscreen helps protect your skin by blocking the UV rays, meaning you can stay in the sun longer without getting a sunburn. (bit.ly/3DXgy5k)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. Select the hypothesis (Circle one):

A. Mirrors reflect objects and bounce light rays.

GOAL: To learn about ultraviolet (UV) light.

WHAT GOES HOME: Polarized filters, Pipe cleaner with beads

PROCEDURE:

1. Show students the **Electromagnetic Spectrum worksheet** and discuss different types of light, especially ultraviolet (UV) light.

<u>Discussion Prompts:</u>

- *Is all light the same?*
- *What are some of the different kinds of light?*
- *Where do we use different types of electromagnetic rays? (radio, microwaves, infrared night goggles!)*
- *How can we test to see if the sun is releasing something like UV rays if we can't see UV light?*

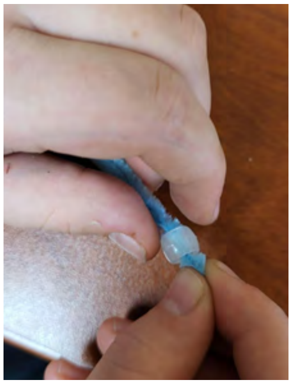
2. Give each student **two UV color-changing beads and a pipe cleaner**.
3. Have your scientists thread one bead onto the pipe cleaner and loop the pipe cleaner to lock the bead in place. Then repeat with the second bead on the other side of the pipe cleaner (Photos 7.5 - 7.6).
4. Take the students outside if possible, however indoors next to a non-tinted window will still work. If it's cloudy outside, that's okay. The activity should still work but might take longer to see the effects.
5. Have students make a <u>hypothesis</u> about what will happen once we expose the beads to light.
6. Expose their beads to the sun until the beads change colors (Photo 7.7).

<u>Discussion Prompts:</u>

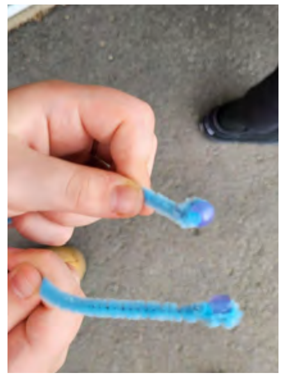
- *What happened when the beads were exposed to the sun? How is that similar to what happens when people are exposed to too much sun?*
- *Would this experiment be different on a cloudy day vs sunny day? Why/why not?*
- *If UV can cause sunburned skin, can it also cause sunburned eyes? (Yes!)*
- *What effect might polarized lenses have on our beads (and our eyes)?*

7. Discuss what's happening and how UV light affects the beads (and also our skin!) even though we can't see it.
8. Show students a polarized filter and remind them that it blocks out about half of all light rays passing through it.
9. Have scientists hold one hand flat with the pipe cleaner/beads laying on their hand.
10. Each scientist can cover one of the beads with the polarized filter and leave the other one uncovered (Photo 7.8).
11. Expose the beads to outdoor light at the same time.
12. After one minute, remove the polarized filter and quickly ask students to compare the brightness of the beads.
    a. It may work best if you move into the shade before removing the filter.

ACTIVITY PHOTOS:

7.5


7.6


7.7


7.8


ACTIVITY 4: GLOWING STREAK, GLOWING WATER

TIME: 15 Minutes

SOURCE: bit.ly/3OW5ATM

Supplies	#
Cups (20oz, plastic)	1
Cups (9oz, plastic, punch)	4
Highlighters (yellow)	4
LED Lights (blue)	4
Markers (yellow)	1
Newspaper	
Paper Towels (rolls)	1
Water (oz)	16
Worksheets	**#**
Electromagnetic Spectrum	1
Paper (8.5inx11in, sheets, white)	4

BACKGROUND:

A black light gives out light in the ultraviolet (UV) range. The UV light is invisible to our eyes, but when the black light shines on something fluorescent, some of the UV light gets converted and reflected back to us as visible light, which we see as a glow. There are lots of uses for fluorescence. Some light bulbs are fluorescent. Electricity adds energy to a gas inside, and that gas gives off UV light. The UV light hits a fluorescent coating inside the bulb, making it glow. That's why sometimes lights start out dim and get brighter the longer they are on - it takes a while to build up enough UV light to get the coating to fluoresce and glow. Some scorpions fluoresce. Their exoskeleton (the hard outer layer) has chemicals inside of it that glow under a black light. No one knows why scorpions glow, but it is possible the glowing is a remnant from evolving in a low oxygen atmosphere. It could also help them recognize each other or protect them from parasites. (bit.ly/47HVSfg, bit.ly/3QD9O3O)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. Select the hypothesis (Circle one):

A. Mirrors reflect objects and bounce light rays.

GOAL: To learn how UV light can activate fluorescence in highlighter pen ink.

WHAT GOES HOME: Nothing

PROCEDURE:

1. **Tell scientists:** Jose Carlos Rubio Avalos, a materials scientist and engineer from Mexico, invented glow-in-the-dark cement in 2015! This material is expected to be useful in building new buildings and parking lots that will be lit up using the cement. Let's be materials scientists like Dr. Rubio Avalos and explore things that glow and how to use them.
2. Put students into groups of 4. Each group will get **a piece of paper prepped with a yellow marker rectangle on it, and a yellow highlighter**.
3. Give each group a **blue LED light** (blue is close to ultraviolet on the electromagnetic spectrum).
4. Turn off the lights in the room. If turning off the lights does not seem dark enough, encourage students to conduct the experiment under their desks, under their coats, or move to a darker corner of the room.
5. Have the students hypothesize what will happen once we shine a blue light onto the patch of yellow marker.

   Discussion Prompts:

   - *What do you think will happen when we shine UV light on the yellow marker?*
   - *What do you think will happen when we shine UV light on the highlighter rectangle?*

6. Have a student in each group shine the blue light on the patch of yellow marker, and let the groups discuss what they see.
7. Have another student in each group use the highlighter to draw and fill in a second rectangle on the other half of the paper (Photo 7.9).
8. Have students hypothesize about what will happen when the blue light is shined onto the patch of highlighter.

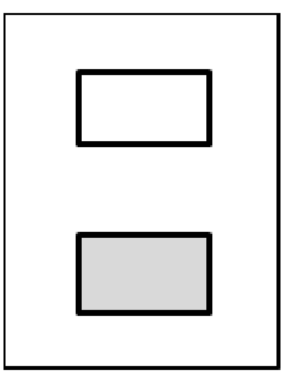
9. Have a different student in each group shine the blue LED onto the highlighter rectangle.
10. Explain to students that the highlighter is <u>fluorescent</u>, meaning that it can absorb UV light and emit it as visible light. The blue light excites the fluorescent dye in the highlighter which reflects light back to us as a glow that we can see.
11. Turn the lights back on and give each student **one 9oz plastic cup half-filled with water** (from prep). Make **paper towels** available. Cover the table with **newspaper** if desired.

<u>Discussion Prompts:</u>

- *What do you think is going on? How is the highlighter different from the plain yellow marker?*
- *What would happen if we put the highlighter into water?*
- *Why did the highlighter ink stop glowing when you turned the lights off?*

12. Have scientists uncap the highlighter, then take turns swirling the highlighter around in the water with the tip down. The highlighter should stay in the cup while students trade it around (Photo 7.10).
13. Once the dye has seeped into the water, have students get their LED lights ready (don't turn them on yet), and turn off the room lights.
14. Observe what the water looks like without the LED on.
15. Have students <u>hypothesize</u> about what will happen once they shine their blue LED lights on their water.
16. Have a student in each group aim their blue LED light towards the water and turn it on. Students will observe the water glowing.
17. Invite students to discuss what happened and whether the water glowed by itself or if it needed light from a different source (e.g., blue LED light) to emit the light back outward as a glow.

<u>ACTIVITY PHOTOS:</u>



7.9

7.10

ACTIVITY 5: YOU CAN GLOW YOUR OWN WAY

TIME: 10 Minutes

SOURCE: *Exploring the Science of Light* by Exploratorium.

Supplies	#
LED Lights (blue)	4
LED Lights (green)	4
LED Lights (white)	4
Worksheets	**#**
Glow Paper (1/2 sheets)	4

BACKGROUND:

In the previous activity (Glowing Streak, Glowing Water), you learned how highlighters take in UV light and release it as bright neon glow: fluorescence. In this activity, you will learn about a different kind of glow: phosphorescence! Using phosphorescence, materials can take in visible and UV light and release that light slowly as a glow. Unlike fluorescence, which only releases light when a light source is shining on it, phosphorescence releases light slowly over time, which allows it to glow in the dark with no light source. All glowing things need some kind of energy, though. As you will learn, the glow sheets need to be recharged to continue glowing.

Phosphorescence was named because the first materials discovered with the property contained "phosphors." Now, however, there are many phosphorescent compounds, and they can glow in every shade of the rainbow! *(Exploring the Science of Light* by Exploratorium*)*

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. Select the hypothesis (Circle one):

A. Mirrors reflect objects and bounce light rays.

GOAL: Learn how phosphorescence allows objects to glow for extended periods of time using Glow Paper.

WHAT GOES HOME: Glow Paper - can be cut after activity to allow everyone to take a piece home

<u>PROCEDURE</u>:

1. Facilitate a brainstorming session about things that keep glowing even after the lights are turned off (such as glow-in-the-dark stars, night lights, Silly Putty). This can be done in a Pair & Share or as a class.
2. Have students gather in four groups. Give each group a **piece of Glow Paper** and ask them to observe the piece of paper and talk about what they notice about it.
3. Tell students that you are going to turn off the lights, during which they should observe their papers (without touching).
4. Have students <u>hypothesize</u> about what will happen to the paper once the lights are off.
5. Turn off the lights for 5 seconds and allow students time to observe their paper. Depending on the strength of the fluorescent classroom lighting and the amount of background light coming in while the lights are off, students may observe either nothing or a faint glow from their papers.

   <u>Discussion Prompts:</u>

   - *How are glow-in-the-dark items different from highlighter ink?*
   - *What happened to your paper? Was your hypothesis correct?*
   - *How could we get the paper to glow brighter when the lights are off?*

6. Give each group **one blue, one green, and one white LED light**.
7. Have students decide which group member will use each color of light and which group member will be in charge of the paper.
8. The student who is in charge of the paper will spread their fingers over the half sheet of Glow Paper, making sure their fingers are separated.

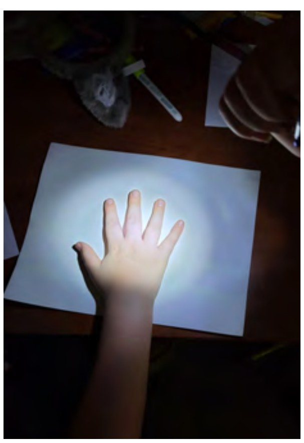
   <u>Discussion Prompts:</u>

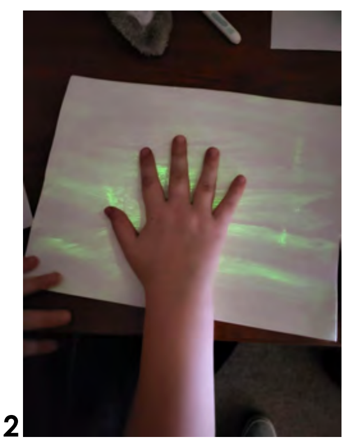
   - *Why do you think we are putting a hand over part of the Glow Paper?*
   - *How do you think the area blocked by the hand will compare to the area we will shine the lights on? Will it be brighter or darker?*
   - *What happened? Why?*

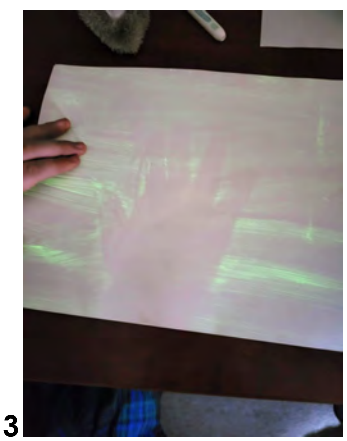
9. Once the paper-student's hands are in position, invite the other students to turn on their LED lights and shine them directly onto the paper, over and around the student's hand. The paper-student's hand should remain in place while this step proceeds (Photo 7.11).
10. While the above step is happening, ask students to make another <u>hypothesis</u> about what will happen to the paper once you turn the lights off.
11. After about 30 seconds, turn the lights off again. Students should turn off or cover their LED lights at the same time (Photo 7.12).

12. Once lights are off (or hidden), invite students to observe their glow paper. They should see the shape of the fingers silhouetted against the glowing green paper. This is phosphorescence in action (Photo 7.13)!
13. After the glow has faded, turn the room lights on again.
14. Discuss what happened: The paper glowed brighter, but only where the LED lights shone on it. Why?
15. Repeat Steps 6-10, rotating who uses which color of light and whose hand is on the paper until everyone has a turn.
16. If desired, students can test some additional variables: using something other than their hand to block the light from the paper, using combinations of the different colors of lights versus each light individually, placing the lights closer or farther from the paper, and whatever else they can think of!
17. ***COOL TRICK:*** have students hold the blue LED light very close to the Glow Paper and see what happens if they trace a design over its surface. A glowing trail should follow the LED light like glow painting (Photo 7.14)!

ACTIVITY PHOTOS:

7.11


7.12


7.13


7.14


ACTIVITY 6: POST-SURVEYS & DAILY DEBRIEF

TIME: 10 Minutes

Supplies	**#**
Pencils	16
Worksheets	**#**
Survey Answers	1
Post-Surveys	16

GOAL: Reflect on what was explored during the activities and relate to students' own lives and administer surveys to your class.

PROCEDURE:

1. Gather students in a circle.
2. Ask questions that facilitate a thoughtful reflection of the day's lessons. Questions may be considered in a Pair & Share model.
3. If you are short on time, have students think about the questions while they are cleaning up from the activities.

   Example questions:

   - *What happened today?*
   - *What was a challenge that you overcame?*
   - *Can you think of any animals that glow?*
   - *How does what we learned today apply to your personal life?*

4. Give each student a **Post-Survey worksheet**. Note that the survey is two-sided.
5. Make **pencils** available.
6. Read each survey question aloud and have students write or circle their answers on the worksheet.
7. Assure students that it's okay if they don't know all the answers. Make their best choices.
8. Afterwards, have students discuss their answers with a neighbor, then invite students to share their answers with the rest of the class.
9. **PLEASE SAVE STUDENTS' SURVEYS & STORE IN A FOLDER.** You can repurpose one of the worksheet envelopes for this!
10. At the end of the term, all surveys must be submitted to the Site Manager.

Name (First + Last): ____________
School: ____________
Date: ____________

AKA Science Post-Survey

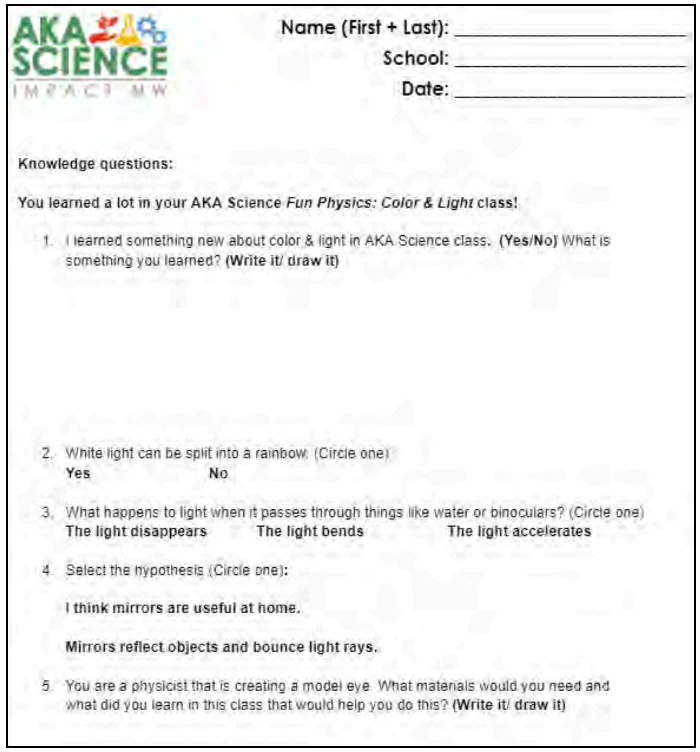
Attitude questions:

You were part of the AKA Science *Fun Physics: Color & Light* class!

1. I liked learning about color & light in AKA Science class. (Circle one)

YES ----------------SORT OF----------------NO

2. I liked doing color & light experiments in AKA Science class.(Circle one)
3. I like color & light and science more than I did before. (Circle one)
4. I felt like a scientist when I was in AKA Science class. (Circle one)
5. I want to do AKA Science class again. (Circle one)



Name (First + Last): ____________
School: ____________
Date: ____________

Knowledge questions:

You learned a lot in your AKA Science *Fun Physics: Color & Light* class!

1. I learned something new about color & light in AKA Science class. **(Yes/No)** What is something you learned? **(Write it/ draw it)**
2. White light can be split into a rainbow. (Circle one)
   Yes **No**
3. What happens to light when it passes through things like water or binoculars? (Circle one)
   The light disappears **The light bends** **The light accelerates**
4. Select the hypothesis (Circle one):
   I think mirrors are useful at home.
   Mirrors reflect objects and bounce light rays.
5. You are a physicist that is creating a model eye. What materials would you need and what did you learn in this class that would help you do this? **(Write it/ draw it)**

<u>CLEAN UP:</u> Implement a fun, daily clean-up routine so that students practice being "truly helpful" to their AKA Science community.

<u>WHAT TO SAVE:</u> Some items will carry over into future classes and others will require proper disposal. We have created a table to help organize your materials by when they will be used again. If an item has a number in the column marked "move to:", all the items used today should be moved to the new class bag. If marked "send home", the items are to go home with your scientists. "Save for SUN, recycle, or discard" means the items can be kept for use by your site or discarded as needed.

******If any students were absent today, make sure to have them take the Post-Survey during the last class.******

******Check all surveys for student names! Ensure names are legible and, if not, please write their names in.******

Fun Physics: Color & Light (Grades 3-5)

Class 7: Curious Colors

Supplies	Move to:	Send home	Save for SUN, recycle, or discard
Beads, UV color changing		X	
Cups, 9oz			X
Cups, 20oz			X
Highlighters, yellow			X
Lab Notebooks	Class 8		
LED lights, blue	Class 8		
LED lights, green	Class 8		
LED lights, white	Class 8		
Markers, yellow			X
Newspaper			X
Paper towels, roll			X
Pencils	Class 8		
Pipe cleaners		X	
Polarized filters, 1.5x2.5in		X	
Tape, Scotch rolls	Class 8		
Water			X
Worksheets			
Electromagnetic Spectrum			X
Glow paper		X	
Paper, white			X
Post Survey Answer Sheet			X
Post-Surveys	Site Manager		

GRAND TOTAL OF WHAT GOES HOME: Polarized lenses, UV beads on pipe cleaners, Glow paper.

CLASS 8: OUTSTANDING OPTICS

Supplies (in class bags)	#
Binoculars, cardboard	16
Lab notebooks	16
LED flashlights	4
LED lights, white	4
Pencils	16
Pushpins	4
Scissors (site provides)	16
Tape, Scotch rolls	4
Yarn, 3ft pieces	16
Yarn, 7ft pieces	16
Worksheets (in envelope)	**#**
Aluminum foil squares, 4x4in	16
How Lenses Bend Light (from Class 1)	2
Paper, black cardstock	32
Parchment paper squares, 4x4in	16
Post Surveys	Any remaining
Snow Goggles, 1/3 sheets	16

PREP STEPS:

None!

VOCABULARY:

- **Binoculars:** A device for making objects that are far away appear nearer and larger, and made of two attached tubes that you hold up to your eyes to look through.
- **Camera Obscura:** A darkened box with a convex lens or aperture for projecting the image of an external object onto a screen inside.
- **Optics:** Optics is the branch of physics that studies the behavior and properties of light, including its interactions with matter and the construction of instruments that use or detect it.

ACTIVITY 1: PAIR & SHARE

TIME: 5 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16
Worksheets	**#**
Post-Surveys	Any remaining

GOAL: Gauge students' knowledge of today's subject and invite questions

PROCEDURE:

1. Pass out **a notebook and a pencil** to each scientist.
2. Ask a question that relates to today's subject. Have the scientists answer the question by drawing or writing in their notebooks or simply thinking about it.

   Example Questions:
   - *Have you ever used an object with lenses?*

3. Ask students to discuss their ideas with their neighbor before inviting students to share what they came up with. This is a "challenge by choice" opportunity and no one is required to share with the class if they are not comfortable.
4. **Administer any remaining post-surveys to students if they were absent during Week 7.**

ACTIVITY 2: SNOW GOGGLES

TIME: 10 Minutes

SOURCE: bit.ly/45kqoKg and Dr. Carrie Buo, AKA Science

Supplies	#
Flashlights	4
LED lights, white	4
Scissors (site provides)	16
Yarn, 3ft pieces	16
Worksheets	**#**
Snow Goggles	16

BACKGROUND:

Most of the time we think of technology as something related to computers or other electronics - something we can plug in and use to make our lives easier. Technology is that and more! An non-electronic example of technology is snow goggles made by Indigenous tribes in and around the Arctic. Snow is made up of millions of tiny crystals that reflect light, which can make it hard to see in bright sunlight. People living in regions that spend much of the year covered in snow needed to find a way to navigate the land in very bright conditions without the sun damaging their eyes. Many of these tribes have created a variation of snow goggles - a piece of bone, wood, or horn that fits over the eyes with a viewing slit in the center. This slit is small enough to see through but blocks most of the light, creating sunglasses without tinted glass! These glasses can even correct mild vision impairments - a technology that many of us today couldn't live without. (bit.ly/3su1No8)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. Select the hypothesis (Circle one):

A. Mirrors reflect objects and bounce light rays.

GOAL: To explore how glare from bright light can be reduced using a traditional snow goggle model.

WHAT GOES HOME: Snow Goggles

PROCEDURE:

1. **Tell scientists:** Indigenous people that live in very snowy areas, like the Yup'ik people of Alaska or the Tunumiits of East Greenland, have been making snow goggles out of bone, wood, and whale baleen (teeth) for thousands of years. These goggles protect eyes from the harsh glare of sunlight reflecting off the white snow, like the driftwood pair made by Yup'ik artist Ayap'run Jack Abraham of Alaska that is displayed in the Smithsonian. Today we will make a version of snow goggles out of paper that will work a bit like the ones Mr. Abraham makes.

   Discussion Prompts:

   - *How do we protect our eyes from bright light?*
   - *Can you think of a way to reduce glare without using sunglasses? (Black under eyes used by athletes)*

2. Pass out a **snow goggles worksheet, a 3-foot piece of yarn, and scissors** to each scientist.
3. Explain that everyone will be making a pair of snow goggles and then testing to see how they reduce glare from bright lights.

4. Have your scientists cut out the glasses along the solid outline and cut the slit in the middle. If cutting out the middle is difficult, have your scientists fold the glasses to make cutting easier (Photos 8.1 - 8.2).
5. Ask everyone to make a hypothesis about whether their glasses will protect their eyes from bright light.
6. Pair scientists and pass out **one white LED OR one flashlight** to each pair. Explain that because we don't have a snow-covered landscape you have to test if the glasses work in a different way.
7. Have one scientist in each pair turn on the flashlight or LED and hold it above their partner's head (Photo 8.3). The light holder should move the flashlight until the other student can see the glare of light on the side of their nose. Now have the scientist under the light hold the glasses over their eyes and the glare will disappear (Photo 8.4)!
8. Scientists can switch roles so each child is able to see the light-blocking effects of the glasses.

Discussion Prompts:

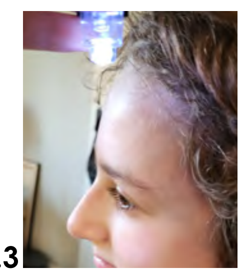
- *Why do you think the goggles reduce glare?*
- *Is there a way to modify the goggles to make them even more effective?*

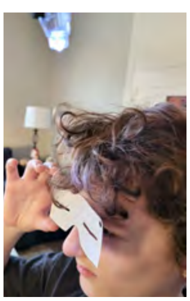
9. Thread the yarn through the holes in the top of the glasses. Scientists can help each other tie the yarn behind their heads to hold the glasses in place (Photo 8.5).

ACTIVITY PHOTOS:

8.1


8.2


8.3


8.4


8.5


ACTIVITY 3: BINOCULARS

TIME: 15 Minutes

SOURCE: Sarah Andersen, Oregon Health Career Center

Supplies	#
Binoculars	16
Pencils	16
Tape (rolls, Scotch)	1
Yarn (7ft pieces)	16
Worksheets	**#**
How Lenses Bend Light	2

BACKGROUND:

Do you remember Class 1 when you learned about convex and concave lenses? Putting those lenses together, you can see an image in the distance that looks much larger through binoculars! That's because of the way the two lenses bend the light that enters your eyes. Binoculars are commonly used for safely viewing wildlife. When you take your binoculars home, go outside and see what you can spot! (bit.ly/3sflCiU)

SURVEY CONNECTION:

★ This activity is linked to the following survey question:

Q. What happens to light when it passes through things like water or binoculars?

A. The light bends

GOAL: To learn how the lenses bend light and function together in binoculars.

WHAT GOES HOME: Binoculars

PROCEDURE:

1. Give each student a pair of **binoculars and a pencil**.
2. Have the **worksheet How Lenses Bend Light** available for use.

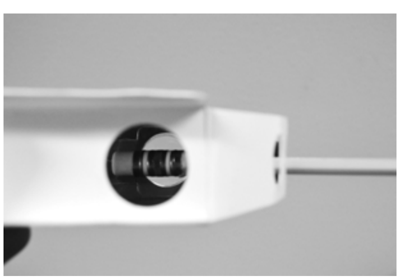
Discussion Prompts:

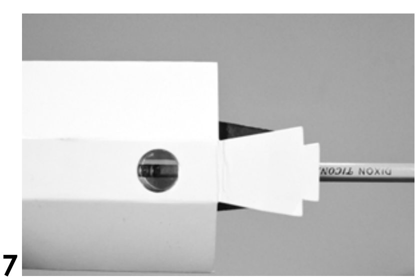
- *Have you ever used binoculars before?*
- *Do you remember how lenses bend light? What did we learn about this in the first class?*
- *What are the parts of these binoculars? Do you recognize anything specific about the lenses?*

3. Have students open the binoculars but wait to push the tabs on the side together.
4. Have students hold the binoculars at a comfortable distance from their face, angled so they can see through the larger set of lenses.
5. Have students put the pencil in the space through the left or right gap in the binoculars. It's most helpful to put it in eraser-side first with the lettering pointing towards students (Photo 8.6).
6. Have students remove the pencil and turn the binoculars around so they're looking through the smaller lenses.
7. Have students repeat step 4 (Photo 8.7).
8. Have students close the tabs on the sides of their binoculars and hold the small lenses up to their eyes (with the larger lenses pointing outward) and discuss what they see.
9. Have students turn their binoculars around to look through the bigger lenses and discuss what they see.
10. Have students look at their pencil through the large and small lenses.
11. Allow students time to explore different ways of looking through the binoculars and to make observations of distant objects.
12. If the students are interested in playing a game, tape **one 7ft piece of yarn** somewhere on the ground in an open space.
13. <u>Have students</u>:
    a. Stand at one end of the line.
    b. Put the large lenses of the binoculars up to their eyes (so everything looks smaller, and their feet seem far away).
    c. One at a time, look down through the binoculars and try to walk the line as straight as possible.

14. OPTIONAL: Give every scientist a **7ft piece of yarn** to loop through their binoculars. Once the yarn is tied they can carry the binoculars around their necks.
15. If time allows, take students outside to explore with their binoculars. Ask them if they can see any wildlife, or anything surprising in the distance. **NOTE: *<u>DO NOT</u>* LOOK AT THE SUN WITH THE BINOCULARS.**

<u>ACTIVITY PHOTOS:</u>

8.6


8.7


ACTIVITY 4: CAMERA OBSCURA

TIME: 25 Minutes

SOURCE: Science Works-65 Experiments that Introduce the Fun and Wonder of Science from the Ontario Science Center

Supplies	**#**
Pushpins	4
Scissors (site provides)	16
Tape (scotch, rolls)	4
Worksheets	**#**
Aluminum Foil (squares, 4in)	16
Paper (cardstock, black)	32
Parchment Paper (square, 4in)	16

BACKGROUND:

A camera obscura, or pinhole camera, is a tool used to project images onto a surface. The invention of early photography was based on the model of the camera obscura (using photo-reactive materials, like film, in place of the parchment paper in our model). At its simplest, the camera obscura is a box (which may be room-sized) with a small opening (i.e., pinhole) on one side. Light will pass through the pinhole and strike a specific part of the back wall, forming a projection of the scene outside the box. As the pinhole is made smaller, the image gets sharper, but the light-sensitivity decreases. In this set-up, the image is always upside-down, because light forced through a pinhole crosses over itself. It is possible to project a "right-side-up" image using mirrors. In this activity, we use a tube instead of a box, and parchment paper as a projection surface instead of a wall.

GOAL: To understand how a pinhole can be used to project an image, and to see the world upside-down.

WHAT GOES HOME: Camera Obscura

PROCEDURE:

1. Give each student **two sheets of black cardstock, an aluminum foil square, a parchment paper square, and a pair of scissors**. Make **tape and pushpins** available. Explain that they will be building their own camera obscura.

   Discussion Prompts:

   - *Have you ever used or seen a projector before?*
   - *Do you think we could make our own mini projection booth?*

2. Have students roll one of their cardstock sheets into a cylindrical tube 8.5in tall, and approximately 2-3 inches in diameter, and tape it along the loose edge to ensure the tube doesn't unroll. The diameter doesn't need to be exact, but the tube should be thin enough that they can comfortably hold it in one hand.
3. Have students fold their foil square over one of the tube's open ends, and tape it down securely so that the opening is entirely covered by foil. It may be easier for students to do this in pairs (e.g., one student could hold the foil in place while the other tapes). Be very careful not to rip or puncture the foil during this process. This will be the pinhole tube.
4. Once the foil is in place, have students use a pushpin to make a small hole in the center of the foil circle now covering one end of the pinhole tube, then have students set their first tubes aside.
5. Have students roll their second cardstock sheet into another cylindrical tube, also 8.5in tall, but just slightly narrower in diameter than they first, and tape it along the loose edge to ensure the tube doesn't unroll. The second tube should be able to fit snugly inside the first. Test this and adjust the tube size accordingly before moving on to the next step (Photo 8.8).
6. Have students fold their parchment paper square over one of the second tube's open ends, and tape it down securely so that the tube's opening is entirely covered by the parchment paper. This will be the screen tube. Note that it may be easier for students to do this in pairs.
7. Have students insert their screen tube into the pinhole tube. The screen tube should be snug enough that it stays in position on its own, but not so tight that it is overly difficult to insert, remove, or move back and forth (Photo 8.9).
8. Have students look through the uncovered opening in the nested tube set-up, towards a brightly lit area (at a lamp, or out a window from inside works best), and slide the screen tube in and out of the pinhole tube to focus the image that appears on the parchment paper.

SAFETY NOTE: Do not look directly at the sun! This can damage eyes, even through the parchment paper.

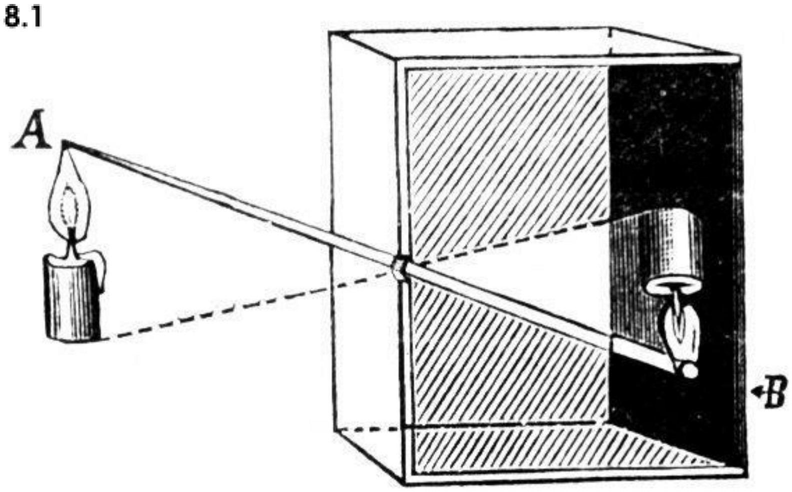
Discussion Prompts:

- *What do you see through your pinhole camera?*
- *Is it upside down or right-side up? Why do you think that is?*
- *How could we make this work like a real camera? Where would we put the film?*

9. Have students discuss what they see through their pinhole cameras, or what they notice about the images projected on the parchment paper screen (Photo 8.10).
10. Explain that the reason the images they see appear upside down is because waves of light travel in very straight paths. The light coming through the pinhole from the top of the scene

they're looking at must be traveling diagonally to hit the pinhole from a point higher up. It continues on that very straight, diagonal path after traveling through the pinhole, and so is now lower than the pinhole itself. The same thing is happening in reverse for the light coming from the bottom of the scene they're looking at, and so the bottom becomes the top (Diagram 8.1).

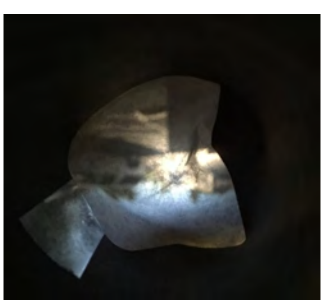
8.1



ACTIVITY PHOTOS:

8.8

8.9



8.10

ACTIVITY 5: WRAP UP!

TIME: 5 Minutes

GOAL: Reflect on what was explored during the activities and relate to students' own lives.

PROCEDURE:

1. Gather students in a circle.
2. Ask questions that facilitate a thoughtful reflection of the day's lessons. Questions may be considered in a Pair & Share model.
3. If you are short on time, have students think about the questions while they are cleaning up from the activities.

Example questions:

- *What happened today?*
- *What was a challenge that you overcame?*
- *What would we do if we had more time?*
- *How does what we learned today apply to your personal life?*
- *What was the best thing you learned in AKA Science class?*

CLEAN UP: Implement a fun, daily clean-up routine so that students practice being "truly helpful" to their AKA Science community.

WHAT TO SAVE: Any remaining items can be sent home (at your discretion), saved for use in other programs, or discarded/recycled. Unused items or items such as rulers, lenses, pitchers, plastic bowls, and flashlights can be kept or returned to AKA Science. **Please do not return used plastic cups, spoons, or food items such as milk powder.**

******Make sure all students have completed the Post-Survey!******

Fun Physics: Color & Light (Grades 3-5)

Class 8: Outstanding Optics

Supplies	Give to Site Manager	Send home	Save for SUN, recycle, or discard
Binoculars, cardboard		X	
Lab notebooks		X	
LED flashlights			X
LED lights, blue		X	
LED lights, green		X	
LED lights, red		X	
LED lights, white		X	
Pencils		X	
Pushpins			X
Scissors (site provides)			X
Tape, Scotch rolls			X
Yarn, 3ft pieces		X	
Yarn, 7ft pieces		X	
Worksheets			
Aluminum foil squares, 4x4in		X	
How Lenses Bend Light			X
Paper, black cardstock		X	
Parchment paper squares, 4x4in		X	
Snow Goggles, 1/3 sheets		X	
Surveys (all)	X		

GRAND TOTAL OF WHAT GOES HOME: Lab notebooks, pencils, snow goggles, binoculars, camera obscura, one LED light per person.

REMINDER: Give completed surveys to your manager

THANK YOU!

Thank you for being a part of AKA Science! We hope you and your students enjoyed the program. Thank you!

IMPACT NW
YOUTH & FAMILY SERVICES

In partnership with

Genentech | Oregon Community Foundation | portland children's levy | yd Youth Development Division | First Tech