Fun Physics: Color & Light (Grades K-2)

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

- **Every class will have a book recommendation for the day**. These books tie in to the day's lesson and can be found at local libraries or as a read-aloud on YouTube.
- **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.**
- **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 could you learn from this?*
    2. *How could you safely try this experiment again in a different way?*
    3. *What did you do today that you're proud of?*

CLASS 1: SURPRISING EYES

Supplies (in class bags)	#
Bug eye viewers	16
Butcher Paper (sheet, folded) *in bottom of kit box*	1
Crayons, black	4
Crayons, box	2
Lab Notebooks	16
LED light, blue	4
LED light, green	4
LED light, red	4
LED light, white	4
Markers, black, washable	2
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
Insect vision	4
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.

VOCABULARY:

- **Binocular vision:** Vision using two eyes with overlapping fields of view, allowing good perception of depth.
- **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 high, thumb down is rating something low, 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 such as: Go around the circle and state your name + your favorite animal.
2. The rest of the group repeats it back (name + favorite animal.)

3. The next person states their name + their favorite animal AND the last person's name + favorite animal.
4. The next person after that says their name/animal AND the last two students' names/animals, until the very last person to share is saying everyone's name + favorite animal.
5. <u>Alternatively</u>, you can just have each person share then have the whole class repeat back then challenge one or two students to try to remember everyone's name/animal.
6. <u>Alternatively</u>, If name + favorite animal isn't your cup of tea, you can try name + a descriptive word that sounds like how your 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. "Disco Donna") and do a disco-dance 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 an s and not a c.)

c) Class Agreements (10 minutes):

1. Once the Name Game is completed, retrieve your **butcher paper and marker** and facilitate a discussion among students to establish a set of 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.

<u>Example questions:</u>

- *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?*

3. Once rules 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

BOOK RECOMMENDATION: *The Doctor with an Eye for Eyes* by Julia Mosca

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

PROCEDURE:

1. Every class will have a book recommendation for the day. These books tie in to the day's lesson and can be found at local libraries or as a read-aloud on YouTube. This is an option if your class responds to picture books.
2. Pass out **a notebook and a pencil** to each scientist.
3. 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.

> **TIP:** A fun way to do this activity is the **Back-to-Back** method. Pair your scientists up and have them stand back-to-back. When you ask today's question out loud, everyone has ~30 seconds to think about it. After 30 seconds call out "Turn around!" The students should quickly turn to face their partners to discuss their ideas.

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?*

4. 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.
5. 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.

6. 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 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 their 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)

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.

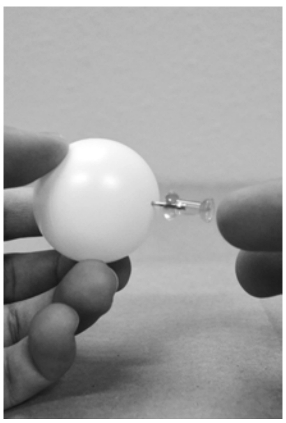
   Discussion Prompts:

   - *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.
13. Ask students to make a hypothesis 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 retina, 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).

ACTIVITY PHOTOS:

1.1

1.2

1.3


ACTIVITY 4: BLIND SPOT

TIME: 5 Minutes

SOURCE: *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:

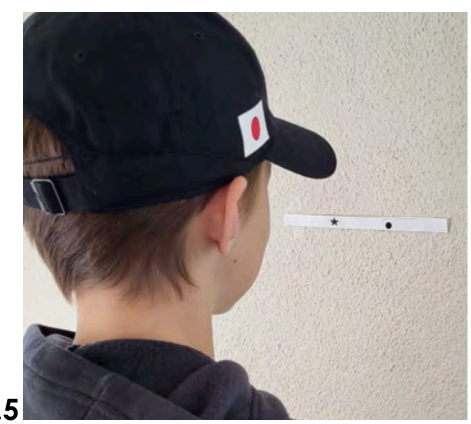
- *What happened?*
- *Why did the dot disappear?*
- *Where else do we talk about blind spots?*

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: ANIMAL AND BUG EYES

TIME: 10 Minutes

SOURCE: bit.ly/3ZWfoRH

Supplies	#
Bug eye viewers	16
Worksheets	**#**
Insect vision	4

BACKGROUND:

Every type of animal sees the world in a different way because their eyes have different uses. Animals that have to hunt usually have very good, forward-focused, binocular vision, so they can find their prey. For example, hawks have very sharp, clear vision, so they can see mice and other small animals from far away. Owls are an extreme example of this. Owl eyes aren't round like human eyes – they're cylindrical, like a can of soup. Cylindrical eyeballs can't roll in their sockets. Instead, the only way an owl can move its eyes is by moving its entire head—but they have great depth perception and movement detection. Animals that must worry about predators often have eyes positioned on the sides of their heads. Each eye sees independently, via monocular vision. This allows these prey animals to have a very wide field of vision, even if it means they may have a hard time seeing something directly in front of them. (bit.ly/46yz0xM)

GOAL: To compare the vision of humans to animals and bugs using bug eye viewers.

WHAT GOES HOME: Bug eye viewer

PROCEDURE:

1. **Tell scientists:** We humans see the world through two eyes in the front of our heads. How would the world look different if our eyes were in different places or if we had a different type of eye? Let's find out!
2. Have students:
    a. Press both hands together, palm to palm with fingers up.
    b. Gently press their thumbs in between their eyes against their nose (dividing their vision in two).
    c. Let their knuckles relax outward (Photo 1.6)
    d. Look around the room to test how their vision is different.

3. VERY SLOWLY AND CAREFULLY, have students try walking around.

Discussion Prompts:

- *Can you think of any animals that see this way?*
- *How does this change what you see?*
- *Was walking easier or more difficult?*

4. Have students make 0's or circles with their hands, then place these circles over their eyes like binoculars and look around (Photo 1.7).

   Discussion Prompts:

   - *Can you think of any animals that see this way?*
   - *How does this change what you see?*

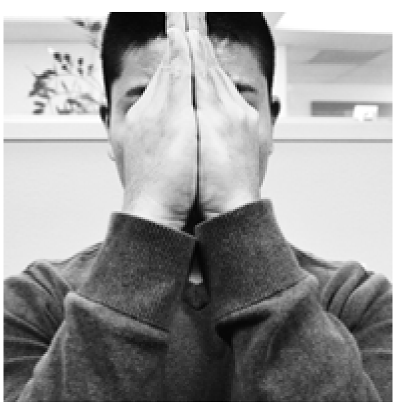
5. Give each scientist a **bug eye viewer**. Give them time to use it to explore the room.

   Discussion Prompts:

   - *Can you think of any animals that see this way?*
   - *How does this change what you see?*
   - *Can you think of any other animals that see things differently than we do?*

6. Show everyone the **Insect Vision worksheets**. You can do this by having students get into four groups and giving each group a sheet, or gather everyone into one large group. Discuss how the pictures compare to what they experienced looking through the bug eye viewers.

ACTIVITY PHOTOS:

1.6 

1.7 

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!******

******Students that miss the first class can take the forms home on the day they begin attending AKA Science.******

Supplies	Move to:	Send home	Save for SUN, recycle, or discard
Bug eye viewers		X	
Butcher Paper (sheet, folded)	Kit box		
Crayons, black	Class 2		
Crayons, box	Class 2		
Lab Notebooks	Class 2		
LED light, blue	Class 2		
LED light, green	Class 4		
LED light, red	Class 4		
LED light, white	Class 4		
Markers, black, washable	Class 6		
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	
Insect vision			X
Supply Advisories		X	

GRAND TOTAL OF WHAT GOES HOME: Model eye, blind spot strip, bug eye viewer, 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	8
Eye patches	16
Highlighters, yellow	16
Lab notebooks	16
LED lights, blue	4
Mirrors, 2x3in	16
Pencils	16
Pennies	16
Scissors (site provides)	16
Worksheets (in envelopes)	**#**
3D Images (double-sided half sheet)	16
Bee vision	4
Paper, white, full sheet	16
Red flower (half sheets)	16
Secret Decoder Message (quarter sheets)	16

PREP STEPS:

- **Act 3:** If present, peel plastic film from the front of all 2x2 inch mirrors.

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.
- **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 recognizes not only the ancestral lands in an area, 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

BOOK RECOMMENDATION: *Eye by Eye* by Sara Levine

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

PROCEDURE:

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

   Example Questions:
   - *How do our eyes work?*
   - *Would having more eyes change the way we see?*
   - *Can you name any parts of the eye?*
   - *How are our eyes like the eyes of animals or bugs?*

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.

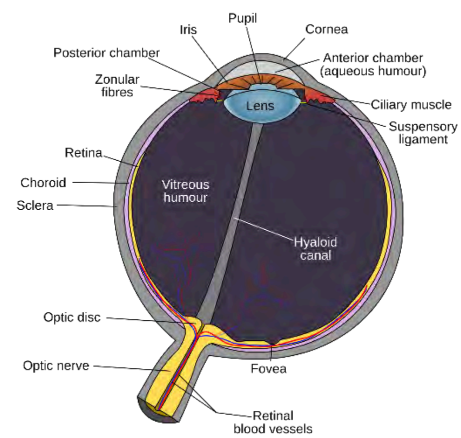
ACTIVITY 3: EYE EXPLORATIONS

TIME: 10 Minutes

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

Supplies	#
Mirrors (2inx3in)	16

BACKGROUND:



Your eyes are pretty amazing, and you need them to see color and light! Light passes through the cornea into 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 retina on the back of your eye and 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)

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.

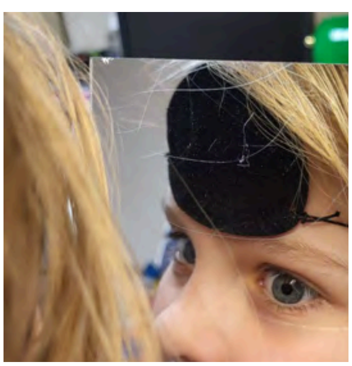
   Discussion Prompts:

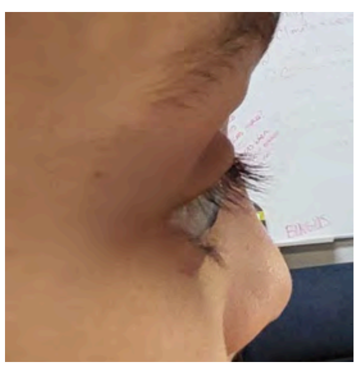
   - *What did you see?*
   - *Did your pupils get bigger or smaller?*
   - *How fast do your pupils respond?*
   - *Why does your pupil do that?*
   - *Do you think we could see another part of our eye if we look a different way?*

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. They may also be able to see blood vessels on the sclera, or white part, of the eye.

8. Discuss the scientists' observations of their own and each other's eyes.

ACTIVITY PHOTOS:

2.1


2.2


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 or things that use binocular vision. 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. 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. (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 scientist an **eye patch and a pencil**.
3. Give each pair **2 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 2.3).
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.

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 (Photo 2.4).
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?*

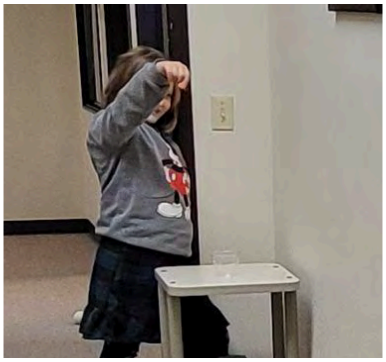
OPTIONAL:

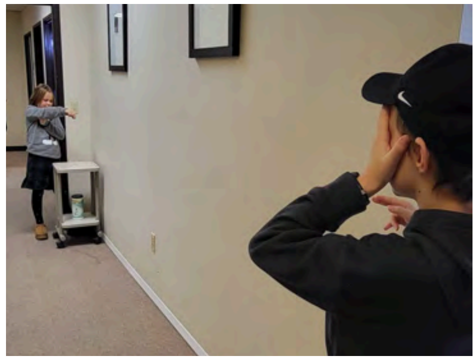
1. Tell students that even though our eyes work together, one eye is usually dominant.
2. Ask students to make a hypothesis about which eye they think is their dominant eye.
3. Have students make a circle with their thumb and index finger.
4. Focus on an object in the distance (like a corner of the ceiling).
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?*

ACTIVITY PHOTOS:

2.3 

2.4 

ACTIVITY 5: SEE LIKE A BEE

TIME: 10 Minutes

SOURCE: Dr. Carrie Buo, AKA Science

Supplies	#
Highlighters	16
LED lights, blue	4
Worksheets	**#**
Bee Vision	4
Red flower (half sheets)	16

BACKGROUND:

Many animals see color differently than we do. Animals that eat specific types of plants have eyes that see those plants best. Bees can see ultraviolet light, a wavelength of light that humans can't see. This allows them to see where flowers store their nectar, creating something like a landing pad for bees and other pollinators. This vision is super important for us because the USDA estimates that 80% of insect crop pollination is accomplished by bees! That means that without bees we wouldn't have almonds, apples, pumpkins, and many other fruits and vegetables. Thankfully these super pollinators can use their exceptional color vision to find the right plants to pollinate. The activity today isn't an exact representation of bee vision because there's no way for us to truly see the same color spectrum as they do. This activity lets us come close to insect vision in a fun, easy way. (bit.ly/3stJmQr)

GOAL: To demonstrate the difference between insect vision and human vision within the color spectrum.

WHAT GOES HOME: Red flower worksheet, Highlighter

PROCEDURE:

1. Pass out a **Red Flower worksheet** to each scientist.

   Discussion Prompts:

   - *Do you remember last week when we talked about animal eyes? What did we learn?*
   - *How do insects see differently from the way humans see?*

2. Ask the class to describe the flower on the worksheet (Photo 2.5).
3. Ask your scientists if they think a bee would see the flower in the same way as we see it. Why or why not?
4. Pass out a **highlighter** to each scientist and have them color the center of the flower with it. The center can be colored as a square, circle, or any shape, just make sure they are not coloring the far outside of the petals or the white paper. The highlighter should have little to no visibility on the flower (Photo 2.6).

   Discussion Prompts:

   - *Does the flower look different after you colored some of it with the highlighter?*
   - *Do you think it would look different to a bee? What is your hypothesis?*

5. Have scientists form groups of four and pass out a **blue LED light** to each group.
6. If you are able, turn off the overhead lights.
7. Shine the blue light on the paper flowers. You should see the highlighter light up the middle of the flower even though the rest of the flower looks dark (Photo 2.7)!

   Discussion Prompts:

   - *What do you see?*
   - *Why does it look like this?*

8. Hand out a **Bee Vision Worksheet** to each group.
9. Explain to your scientists that bees can see colors in the UV spectrum, different from what we can see. This flower is similar to what bees can see - many flowers have a UV spot in the center that shows bees and other pollinators where to land and pick up nectar and pollen!
10. Tell your scientists that these are examples of how a bee sees a flower compared to how we see flowers. Our eyes are amazing!

ACTIVITY PHOTOS:

2.5 

2.6 

2.7 

ACTIVITY 6: 3D!

TIME: 15 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)

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 student 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 with **eye patch**) one eye and look only through the red lens while exploring the room (Photo 2.8).
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 2.9).
10. Have students look at the picture through the red lens, then discuss what they see (Photo 2.10).
11. Have students remove their 3D glasses in preparation for the next step.
12. Give each student a **3D Images worksheet**, have them examine it without the 3D glasses on, and discuss what they see.

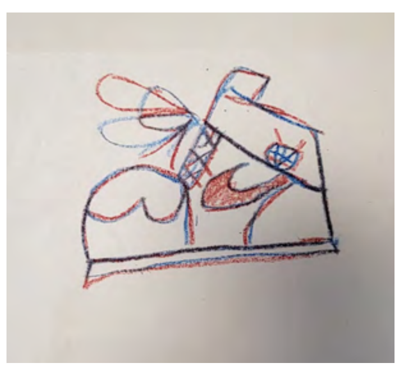
13. Have students look at the worksheets through their 3D glasses. Note: the rock landscape can be slightly challenging to see. Students may need to adjust the focus of their eyes and/or hold the paper further away from them.
14. Have the students discuss what they see and hypothesize what features of 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. If there is time, 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 (Photo 2.11). 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!

ACTIVITY PHOTOS:

2.8 

2.9 

2.10 

2.11 

ACTIVITY 7: 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.

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

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			X
Eye patches		X	
Highlighters		X	
Lab notebooks	Class 3		
LED lights, blue	Class 4		
Mirrors, 2x3in	Class 6		
Pencils	Class 3		
Pennies		X	
Scissors (site provides)			X
Worksheets			
3D Images (double-sided half sheets)		X	
Bee vision			X
Paper (8.5inx11in, sheets, white)		X	
Red flower		X	
Secret Decoder Message (quarter sheets)		X	

GRAND TOTAL OF WHAT GOES HOME: Pennies, eye patches, 3D glasses, 3D worksheets/drawings, red flower worksheets, and highlighters.

CLASS 3: ILLUSTRIOUS ILLUSIONS

Supplies (in class bags)	#
Crayons, black	4
Crayons, blue	4
Crayons, box	4
Crayons, red	4
Filter paper	32
Flip Stick Paper Pieces (in envelope with 2 sets of 16)	32
Lab notebooks	16
Pencils	16
Pushpins	4
Scissors (site provides)	16
Straws	16
Tape, rolls Scotch	4
Wooden tops	16
Yarn, 4ft loops	16
Worksheets (in envelope)	**#**
Benham's Disk, quarter sheet	16
Fishbowl Thaumatrope, half 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

BOOK RECOMMENDATION: *Duck! Rabbit!* by Amy Krouse Rosenthal

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:

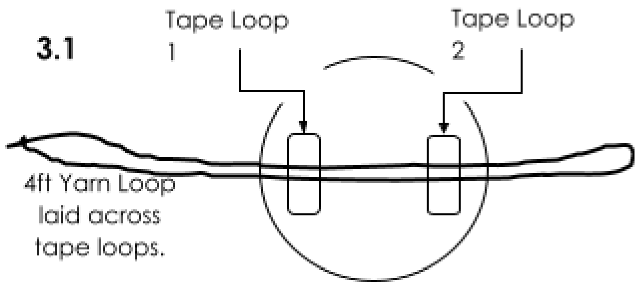
   - *What happens after staring at the black dot and looking away? What do you see?*
   - *Why do you think afterimages happen?*

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. Have students:
    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



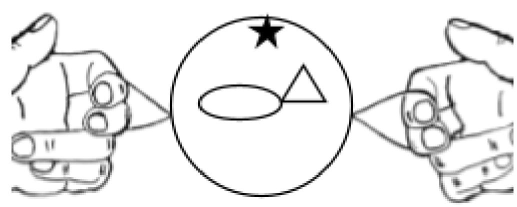
(Fish image is face-down on the table)

Discussion Prompts:

- *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 thaumatrope. 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

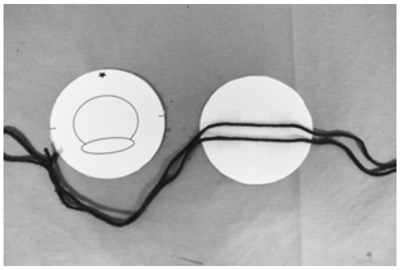


Twirl the thaumatrope to wind it up, then pull gently outward to make the fish appear inside the bowl.

Discussion Prompts:

- *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?*
- *Can you think of another set of drawings to use to make a different illusion?*

ACTIVITY PHOTOS:

3.1 

ACTIVITY 3: NOT IN KANSAS ANYMORE

TIME: 20 Minutes

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

Supplies	#
Filter paper	32
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)

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 sheet, additional drawings on filter paper

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 counterclockwise) and note any differences.

Discussion Prompts:

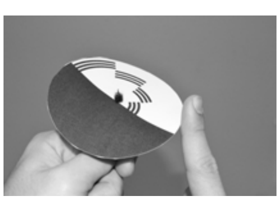
- *Do you observe any differences when you spin the disk in the opposite direction?*
- *Why do you think we see colors when there aren't any?*
- *Do you think other patterns might create similar effects or optical illusions?*

OPTIONAL:

If there is time, hand out **filter paper** to each scientist and allow them to decorate or attempt to design their own optical illusion pattern to put on their wooden top and see what happens!

7. Save wooden tops for a future activity.

ACTIVITY PHOTOS:

3.2 

ACTIVITY 4: FLIP STICKS

TIME: 15 Minutes

SOURCE: bit.ly/3Qhne53

Supplies	#
Crayons, box	4
Flip Stick Paper Pieces (in envelope with 2 sets of 16)	32
Straws	16
Tape, Scotch rolls	4

BACKGROUND:

We already learned about the idea of "persistence of vision" with our Fishbowl Thaumatropes by creating an optical illusion where two images combine into a new, complete picture. In this activity we take it a step further and combine two images into the illusion of movement. Persistence of vision doesn't just mean afterimages and putting fish in bowls, it also means we can trick our brains into thinking still images are moving! "Persistence of vision" inspired the invention of animation! By flashing images very close together, animators fool your brains into thinking that you're seeing a moving image, or "motion picture," as movies were originally called. The 1989 animated version of The Little Mermaid is made up of over one million drawings! (bit.ly/46xLBRT)

GOAL: To reinforce the concept of persistence of vision using flip sticks.

WHAT GOES HOME: Finished Flip Stick

PROCEDURE:

1. Give each student **one straw** and one of each of the **two flip stick paper piece** designs.
2. If time allows, make **crayons** available so students can color the flip stick pieces if they wish (it will be easier to color the pieces prior to the next step). Have **tape** available.
3. Have students:
   a. Lay one of the flip stick pieces face down on the table.
   b. Place a tape loop (sticky on both sides) onto one half of the paper.
   c. Stick the top inch of the straw onto the tape loop.
   d. Place another tape loop over the straw.
   e. Fold the paper piece on the dotted line (Photo 3.3).
   f. Press the folded half onto the loops of tape.

4. The paper should have an image on both sides of the straw.
5. Repeat step 3 with the other paper piece on the other end of the straw.
6. Students should have a straw with an image on both sides.

Discussion Prompts:

- *Thinking about what we have done so far today, what do you think these will do?*
- *How do you think they work?*

7. Have students rub the straw back and forth in their hands with either image on top while looking at the pictures on top. They can then flip the straw over and do the same for the other image. The best speed for viewing the images may vary (Photo 3.4).
8. Have students discuss what they see when they are moving their flip sticks.

ACTIVITY PHOTOS:

3.3 

3.4 

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 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 4		
Crayons, red	Class 6		
Filter paper		X	
Flip Sticks paper bundle		X	
Lab notebooks	Class 4		
Pencils	Class 4		
Pushpins	Class 5		
Scissors (site provides)			X
Straws		X	
Tape, rolls Scotch	Class 4		
Wooden tops	Class 7		
Yarn, 4ft loops		X	
Worksheets			
Benham's Disk, quarter sheet		X	
Fishbowl Thaumatrope, half sheet		X	

GRAND TOTAL OF WHAT GOES HOME: Fishbowl Thaumatrope, Bentham's Disk paper cutout, filter papers, Flip Stick.

CLASS 4: SHADOWLAND

Supplies (in class bags)	#
Crayons, box	4
Dinosaurs, plastic	16
Index cards	16
Lab notebooks	16
LED lights, blue	4
LED lights, green	4
LED lights, red	4
LED lights, white	4
Mirror boards	8
Pencils	16
Tape, Scotch rolls	4
Worksheets (in envelope)	**#**
Hand shadows	16+1
Paper, white, full sheet	32

PREP STEPS:

None!

****NOTE:** Activities in today's class work best if you can turn the lights in the room off or find a darker location. If you absolutely have to do the experiments in a brightly lit area, you may want to consider skipping this class and substituting other activities.

VOCABULARY:

- **Visible Spectrum:** The band of the electromagnetic spectrum that is visible to the human eye. Electromagnetic radiation in this range of wavelengths is called visible light.
- **Wave:** Anything that reflects, refracts, diffracts, and interferes is labeled a wave in the electromagnetic spectrum.
- **Wavelength:** Distance between the top points in a wave. Different colors and sounds have different wavelengths.

ACTIVITY 1: PAIR & SHARE

TIME: 5 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16

BOOK RECOMMENDATION: *Hortense and the Shadow* by Natalia O'Hara

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 are shadows? What makes them?*
   - *Can we see without light?*

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: BRIGHT IDEAS

TIME: 15 Minutes

SOURCE: bit.ly/3FkDlbJ

Supplies	#
Index cards	16
LED lights, blue	4
LED lights, green	4
LED lights, red	4
LED lights, white	4
Mirror boards	8

BACKGROUND:

Light is a form of electromagnetic radiation (or energy) made up of waves in the visible spectrum. We see images because light reflects off of objects and into our eyes. If something blocks the path of light, it creates a shadow. Shadows are created because light waves travel in straight lines. If an object blocks some of the rays from a light source, the rays travel in a straight line toward the object but can't get through. The other rays around them—the ones whose paths aren't blocked—surround the object and provide enough general light to see by. However, the light rays can't bend on their own to fill in the area where the light is blocked—so we see a shadow! Light can also reflect off of surfaces. When that happens, light travels in one direction, bounces off, and travels in another direction. Light travels so fast that shadows and reflections seem to be created instantly. In fact, light travels so quickly that light from the moon, which is 239,000 miles away, reaches Earth in 1.3 seconds! Nothing travels faster than the speed of light! (bit.ly/3tBs989)

GOAL: To explore how light travels.

WHAT GOES HOME: Index card

PROCEDURE:

1. Give each scientist one of the small **green, red, blue, or white LED lights**.
2. Have scientists point their LED at a wall. Don't allow them to turn it on yet.

   Discussion Prompts:

   - *What do you think will happen when the lights are shined on the wall?*
   - *Will the light travel in a straight line?*

3. Ask scientists to point to the place on the wall where they think the light will shine.
4. Turn off the lights in the classroom.
5. Have students shine their light on the wall.
6. Have students stand at the wall and hold their LED light directly up to the wall.
7. Have students SLOWLY walk backward (or sideways) until they can't see the circle of light on the wall anymore.
8. Explain that the circle of light gets bigger the farther students move from the wall because, even though each ray of light travels in a straight line, each ray also leaves the bulb at a slightly different angle and path. The further the light is from the wall, the longer the light rays travel on their distinct paths—spreading farther from each other.
9. Have students trade LED lights with each other so that each student now has a different color light than they started with.
10. Have students repeat steps 6 + 7.
11. Repeat steps 9 + 10 until each student has tried each of the four LED light colors.

Discussion Prompts:

- *Do all the colors of light seem to travel the same distance?*
- *Which color travels the furthest?*

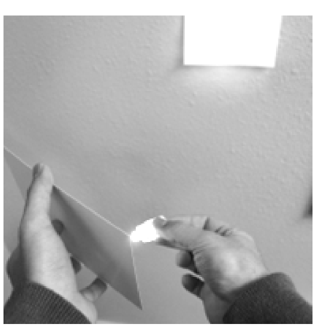
12. Explain to students that different colors of lights are made up of different types of waves, and these waves have different wavelengths that travel at different speeds.
13. Pair students and give each pair an **index card** and a **mirror board sheet**.
14. Have one partner hold the index card and the mirror at an angle to each other. Have the other partner hold the LED light.
15. Challenge students to make the light appear on the index card without shining their LED directly at the card.
16. Allow students time to figure this out. They should point the LED light at the mirror and angle it so the light bounces onto the index card (Photo 4.1).
17. Have students discuss why the mirror worked to redirect the light. Introduce the idea of reflections and explain that some materials bounce light instead of just blocking it.
18. Ask students what they think will happen if something is placed in between the light and the wall.
19. Distribute more index cards so that each student now has an LED light and an index card.
20. Have each student hold their index card a few inches away from the wall.
21. Have each student hold their LED light directly behind the index card (no more than half an inch away from it) and shine the LED light toward the wall with the index card in between.
22. Have students hold their index cards steady and slowly move the LED light farther away from the index card and the wall.

Discussion Prompts:

- *What do you see?*
- *Why is it different than shining the light on the wall without the index card?*

23. Explain that shadows are made when an object blocks some, but not all, of the light from a light source.

ACTIVITY PHOTOS:

4.1 

ACTIVITY 3: ME & MY SHADOW

TIME: 20 Minutes

SOURCE: bit.ly/3S1YBdS

Supplies	#
Crayons, box	4
Dinosaurs, plastic	16
LED lights, blue	4
LED lights, green	4
LED lights, red	4
LED lights, white	4
Pencils	16
Tape (rolls, Scotch)	1
Worksheets	**#**
Paper, white, full sheet	32

BACKGROUND:

During the previous activity we introduced shadows very briefly. You will now continue to explore how shadows are created and can change shape depending on the placement of a light source. Once again you will be best served by a room that can be easily darkened. (bit.ly/3FjHhK3)

GOAL: To learn about the properties of shadows.

WHAT GOES HOME: Drawings, Dinosaur

PROCEDURE:

1. Give each student **a pencil and a sheet of paper**. Make sure students still have their **LED lights** from the last activity.
2. Turn off the lights in the room.
3. Allow students time to experiment. They can hover one hand over the paper, hold their LED light in their other hand, and aim their LED light down at the hovering hand to cast a shadow (Photo 4.2).

   Discussion Prompts:

   - *Can you change the size of your shadow?*
   - *Would a different object have a different shadow shape?*

4. Have students discuss what their hand shadows look like and what they see.
5. Give each student a **dinosaur figurine**.

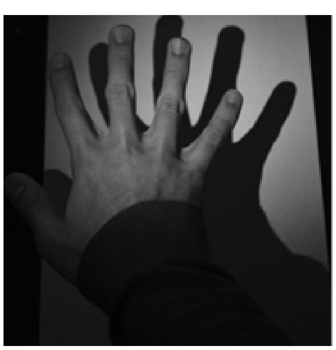
6. Allow students time to create a shadow on their paper with their dinosaur.
7. Have students hold the dinosaur in one hand and the LED light in the other.
8. Have students shine the LED light downward onto the paper from several inches above the paper. Hold the dinosaur in between the paper and the light. Move the dinosaur closer to and farther from the light to see how that changes the size of the shadow (Photos 4.3 - 4.4).
9. Have the students discuss what they observe.

Discussion Prompts:

- *How does the dinosaur shadow size compare to the size of the dinosaur?*
- *Can you make the shadow almost disappear? How?*

10. Have students set the dinosaur on the paper.
11. Allow students time to explore making shadows of different lengths by changing the angle at which their LED light points toward their dinosaur. (Let them discover for themselves that if they bring the light to the side of their dinosaur, its shadow will lengthen, and if they move the light directly above the dinosaur, its shadow will shrink.)
12. Have students pick an angle they like and trace the shadow onto the paper.
13. Have students discuss the ways in which the dinosaur's shadow is similar to and different from the dinosaur figurine.
14. Put students in groups of 3.
15. Give each group three sheets of paper (one for each student). Make pencils, **crayons and tape** available.
16. Have groups tape one sheet of paper on the wall.
17. Challenge the students to see if they can cast the shadow of their own face on the paper.
18. Each student will trace the shadow of another student's profile. One student should hold the LED light (white or green works best), one should stand in profile at the wall (sideways relative to the wall), and the other should trace the student's profile. Each student can decide how large they want their profile to be and change their position accordingly to achieve it.
19. After each student's profile has been traced, allow students to color in their pictures.

ACTIVITY PHOTOS:

4.2


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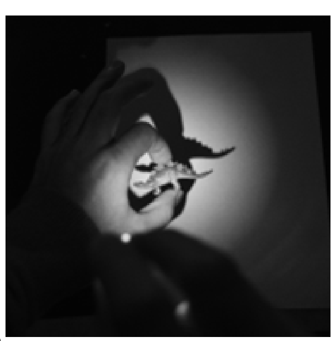

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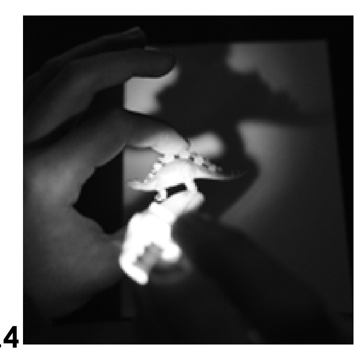


ACTIVITY 4: HAND SHADOWS

TIME: 10 Minutes

SOURCE: Sarah Andersen, Oregon Health Career Center

Supplies	#
LED lights, blue	4
LED lights, green	4
LED lights, red	4
LED lights, white	4
Worksheets	**#**
Hand shadows	16+1

BACKGROUND:

In the last activity, your hand and face made a shadow against the paper because they blocked the light. Did you notice that not all of your shadows were the same color? Depending on the material, position, shape, and size of an object--sometimes an object will block some, but not all, of the light. The less light is blocked, the lighter a shadow will be. The more light that gets blocked, the darker the shadow. Shadow puppetry was invented thousands of years ago in China and India. It was one of the first forms of puppetry. To see a shadow puppet show, go to the Oregon Shadow Theatre website! Their shadows are huge, colorful creations that are held up by sticks and include stories like Pecos Bill, Thumbelina, and Puss in Boots! (bit.ly/3M50Klb)

GOAL: To demonstrate how shadows can be engineered for entertainment.

WHAT GOES HOME: Hand shadow sheet

PROCEDURE:

1. Pair students. Have pairs stand near a wall where they can cast their shadows.
2. Make sure each student has an **LED light**. It's helpful if one of the students in each pair has a white or green light (those colors work best for this activity).
3. Give each student a **Hand Shadows worksheet**. There is one larger sheet with additional shapes to make if your class is interested.

   Discussion Prompts:

   - *Have you ever seen a shadow puppet? How do they work?*
   - *Can you tell a story using shadows?*

4. Turn the lights off in the room.

5. Tell students they can try to imitate the hand shadows shown on the worksheet or they can work together to make up their own hand shadows (Photos 4.5 - 4.6).
6. If you have extra time, students can make up a play with their hand shadows and perform for the rest of the class. Students can also try shining two different colored lights from different angles—they'll see different colored shadows!

Discussion Prompts:

- *Can you create a shape not on the sheet?*
- *Did different color lights change the shadows?*

ACTIVITY PHOTOS:

4.5


4.6


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 shadows?*
- *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, box	Class 6		
Dinosaurs, plastic		X	
Index cards		X	
Lab notebooks	Class 5		
LED lights, blue	Class 7		
LED lights, green	Class 7		
LED lights, red	Class 8		
LED lights, white	Class 7		
Mirror boards	Class 6		
Pencils	Class 5		
Tape, Scotch rolls	Class 5		
Worksheets			
Hand shadows		X	
Paper, white, full sheets		X	

GRAND TOTAL OF WHAT GOES HOME: Index card, drawings, dinosaur, hand shadows worksheet.

CLASS 5: REFRACTION & RAINBOWS

Supplies (in class bags)	#
Bowls, large plastic – *in kit box*	4
Colored filters, blue	16
Colored filters, red	16
Colored filters, yellow	16
Dowels	4
Lab notebooks	16
LED flashlights	4
Newspaper, bundle – *in kit box*	1
Paper towels, roll – *in kit box*	1
Pencils	16
Pitcher – *in kit box*	1
Plastic sheeting squares, 4x4in	16
Play doh, containers	4
Prisms, teardrop	8
Prisms, triangular	8
Pushpins	4
Rainbow viewers	16
Rubber bands, size 16	16
Rulers	4
Scissors (site provides)	16
Sticky tack strip	1
Straw pieces	4
Tape, Scotch rolls	4
Water	
Worksheets (in envelope)	**#**
Color Wheel sheet	2
Paper, construction, black	16

PREP STEPS:

- **Act. 2a:** Divide sticky tack into 4 pieces.
- **Act. 2b:** Fill each large plastic bowl ¾ full of water.
- **Note:** Throughout the class, newspaper is used as needed to protect surfaces and paper towels are for cleaning up liquids.

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).
- **Spectroscope:** Device used to split light into different colors in the light spectrum. Many spectroscopes can record data for research purposes.

ACTIVITY 1: PAIR & SHARE

TIME: 5 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16

BOOK RECOMMENDATION: *Light Waves* by David A. Adler and Anna Raff

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

PROCEDURE:

7. Pass out **a notebook and a pencil** to each scientist.
8. 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 make a rainbow?*
   - *Have you ever tried to touch something under water and it was hard to reach?*

9. 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: 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)

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 **1/4 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 5.1)

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 5.2).
6. Use the ruler to measure the distance from the fish to the top of the water. Have the scientists write this number in their notebooks (Photo 5.1). This is to learn how to use a ruler.
7. 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 or use extra play doh to help the straw stay in place (Photo 5.3).

Discussion Prompts:

- *Why is it important to catch a 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?*

8. 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.
9. Ask the groups to make a hypothesis about whether they will be able to touch the fish underwater on the first try with their "spears".
10. Have one scientist in each group insert the dowel into the straw without moving the straw position (Photo 5.4). 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 (Photo 5.5).

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?*

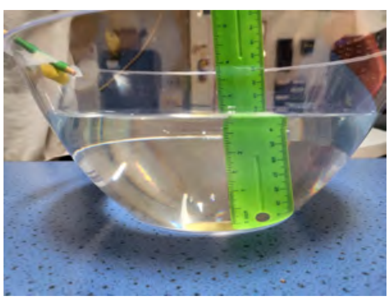
11. Ask groups to adjust the straw to point just below the fish and try again, seeing if they can get closer to the fish.
12. Have your other scientists test the spear fishing, allowing them to switch the play doh fish to their own if they wish.

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 play doh, straw pieces, and sticky tack.

ACTIVITY PHOTOS:

5.1


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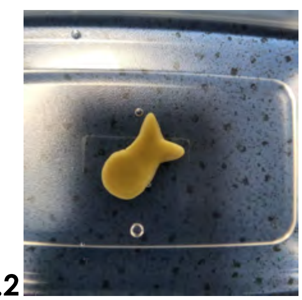

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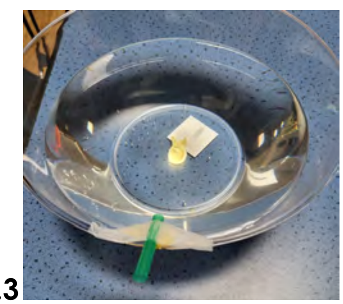

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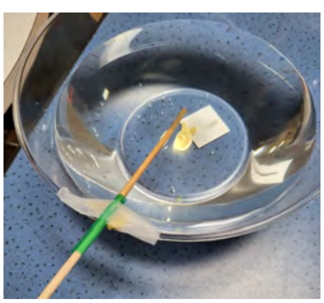

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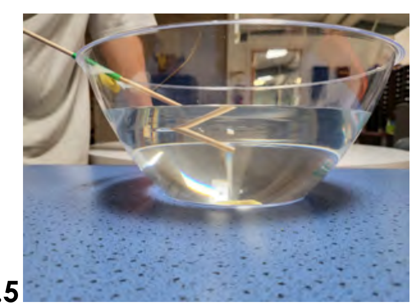


ACTIVITY 3: RAINBOW EXPLORATION

TIME: 20 Minutes

SOURCE: bit.ly/3Yunwbo

Supplies	#
LED flashlights	4
Prisms, teardrop	8
Prisms, triangular	8
Rainbow viewers	16

BACKGROUND:

White light is actually made up of many different colors of light. In this activity we experiment with a couple different ways of separating white light into its component parts: refraction and diffraction. When light passes from the air into a prism, it slows down, and when it leaves the prism, it speeds up again. If the light hits the prism at an angle instead of dead-on, it undergoes refraction—or bending. The angle at which it hits the prism is not the same as the angle it travels inside the prism. 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. The different colors of light, from red to violet, each get bent at slightly different angles: red gets bent the least, violet the most. This causes the colors to fan out and become distinct.

Rainbow viewers, on the other hand, are made of plastic with lots of little grooves in it, called a diffraction grating. The grooves in the diffraction grating act like a net, letting light through some sections and not others. This breaks up the light into its different colors – so you see a rainbow. Prisms refract light so that it bends, revealing all of its colors, but these rainbow viewers diffract light.

It is important to note though, 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 or refracted, a complete rainbow won't appear. Sunlight, however, always contains the full spectrum of visible light colors.

GOAL: To observe how white light can be split into a spectrum of colors through prisms and rainbow viewers.

WHAT GOES HOME: One prism per child, either triangular or teardrop

PROCEDURE:

1. Briefly discuss with students that white light is not actually "white" - it is made up of a lot of different colors.
2. Give each student a **rainbow viewer**.
3. Allow time for students to explore how the viewers work. The viewers work best when looking at something that gives off concentrated white light, like a light bulb or shiny surface. ***Do not*** *aim the rainbow viewer directly at the sun.*
4. 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.
5. Collect the rainbow viewers.
6. Pair students up, and give each pair **one acrylic triangular prism and one crystal teardrop prism**.

   Discussion Prompts:

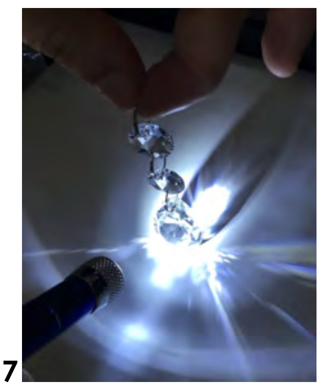
   - *What do you think will happen when we shine light through the prisms?*
   - *How are these like the rainbow viewers? How are they different?*

7. Have the students explore and compare the two prisms. Encourage the students to look through the prisms around the room and discuss what they see with their partner.
8. 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 5.6).
9. Group pairs into groups of four, and pass out an **LED flashlight**.
10. Encourage the students to come up with a hypothesis for what will happen when they shine the flashlight at each of their prisms.
11. Have the students experiment with their flashlight and prisms. It may help to dim the lights in the classroom so that the students can more clearly see what happens with their flashlight beam.
12. 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 a light colored surface or piece of paper to "catch" the light rays coming out of the prisms. The light the surface, the easier it will be to see the prisms' effects.

13. 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 5.7).
14. The acrylic triangular prism will also display the orange and blue color spectrum of the LED light, but in one continuous arch (Photo 5.8).
15. If the sun is visible through a classroom window, you can relocate your students to be nearby the window with their prisms. If not, you should move your class to a sunny area outside (Photo 5.9 - 5.10). ***Do not*** *look directly at the sun, even through a prism!*
16. Have the students experiment with trying to "capture" a ray of sunlight in one of the prisms. If successful, students should be able to observe complete rainbows being refracted!
17. Encourage your students to discuss any differences they observe between sunlight and their flashlights.
18. Return to the classroom and collect the flashlights.

ACTIVITY PHOTOS:

5.6 

5.7 

5.8 

5.9 

5.10 

ACTIVITY 4: 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)

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)

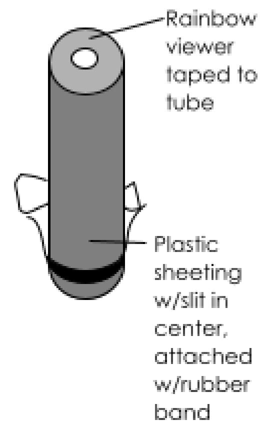
PROCEDURE:

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 push pins** 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 5.11).
   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 5.12).
   g. On the other end of the tube, tape the rainbow viewer over the circular opening (Photo 5.13).



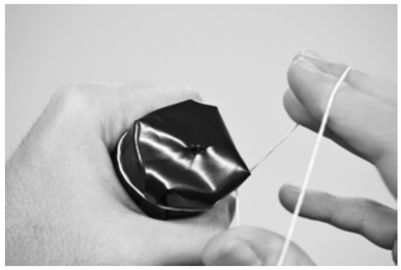
5. Have students look through the rainbow viewer end of the tube and describe what they see. **DO NOT AIM THE SPECTROSCOPE DIRECTLY AT THE SUN.**

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 3 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:

5.11  5.12  5.13 

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
Bowls, large clear plastic			X
Colored filters, blue		X	
Colored filters, red		X	
Colored filters, yellow		X	
Dowels			X
Lab notebooks	Class 6		
LED flashlights	Class 8		
Newspaper	Kit box		
Paper towels roll	Kit box		
Pencils	Class 6		
Pitcher	Kit box		
Plastic sheeting, black 4x4in squares		X	
Play doh			X
Prisms, teardrop		X	
Prisms, triangular		X	
Pushpins	Class 8		
Rainbow viewers		X	
Rubber bands, size 16		X	
Rulers			X
Scissors (site provides)			X
Sticky tack strip			X
Straw pieces			X
Tape, Scotch rolls	Class 6		
Water			X
Worksheets			
Color wheel sheet	Envelope		
Paper, construction black		X	

GRAND TOTAL OF WHAT GOES HOME: Spectroscope, colored filters, one prism per child (either teardrop or triangular).

CLASS 6: MIRROR MIRROR ON THE WALL

Supplies (in class bags)	#
Beads, multicolored tri	128
Crayons, black	4
Crayons, blue	4
Crayons, box	4
Crayons, red	4
Cups, 1oz	16
Lab notebooks	16
Lids, 1oz	16
Markers, black	2
Mirror boards	16
Mirrors, 2x3in	16
Pencils	16
Scissors (site provides)	16
Tape, Scotch rolls	4
Worksheets (in envelope)	**#**
Symmetrical	16

PREP STEPS:

- **Act. 4a:** Place 8 beads in each of the sixteen 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:

- **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

BOOK RECOMMENDATION: *Reflections of Me* by David Lane

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: FUNHOUSE MIRRORS

TIME: 15 Minutes

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

Supplies	#
Mirror boards	16

BACKGROUND:

Normally, light travels in a straight line when it's reflected off of 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: Nothing

PROCEDURE:

1. Give each student a flexible **mirror board sheet**.

   Discussion Prompts:

   - *Why do you see yourself when you look in a mirror?*
   - *What do you think will happen if we bend the mirror?*

3. Have students explore by bending the mirrors and making observations.
4. 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 themselves in the mirror.
5. Next, 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 6.1).
6. They can now try squeezing the mirror in the other direction, so the middle of the mirror is closest to them (Photo 6.2).

   Discussion Prompts:

   - *How did your reflection change when you squeezed the mirror?*
   - *Did your size in the mirror change when you squeezed it? How?*

ACTIVITY PHOTOS:

6.1 

6.2 

ACTIVITY 3: THE SAME ON BOTH SIDES

TIME: 15 Minutes

SOURCE: bit.ly/3tvXWqT

Supplies	#
Crayons, black	4
Crayons, blue	4
Crayons, box	4
Crayons, red	4
Mirrors (2inx3in)	16
Pencils	16
Worksheets	**#**
Symmetrical	16

BACKGROUND:

Nature is full of different kinds of symmetry! The kind this activity is about is called "reflective symmetry". Reflective Symmetry is when one half of an object or image is the mirror image of the other half along a single axis. Almost all animals are symmetrical in some way—our left halves are symmetrical with our right halves. The same is true for birds, horses, fish, etc. A sea star is *radially symmetrical,* meaning it is symmetric around a central point, and it can be divided equally in half infinite ways as long as the axis of division passes through that central point. Are plants symmetrical? Flowers and leaves are often symmetrical, but an entire tree is usually asymmetrical (not symmetrical). Psychologists have found that symmetry is pleasing to look at, so many man-made objects are symmetrical, as well. Can you think of a few examples? How about the Eiffel Tower, smart phones, and water bottles? Symmetry is everywhere! (bit.ly/3M3Lk0Q)

GOAL: To apply the concept of symmetry using mirrors and shapes.

WHAT GOES HOME: Symmetrical worksheet, mirror

PROCEDURE:

1. Introduce the concept of symmetry to your students. Discuss what they think symmetrical means. Explain that symmetry is when something can be divided into two parts along a line, and the parts are perfect reflections of each other.
2. Give each student a **Symmetrical worksheet, a pencil, and a 2inx3in mirror**.
3. Challenge the students to use their mirror to complete the picture of the heart with a reflection.
4. Have students experiment with placing their mirrors on their worksheet.

NOTE: You may need to help students find the correct placement for their mirrors. If they become frustrated, have your students hold the mirror upright directly on the midline of the heart image.

6. Once students have found a way to complete the heart image with reflection, have them use their pencil to trace the edge of the mirror where it crosses through the picture (Photo 6.3).
7. Explain that the line each student just drew is a "line of symmetry". The line perfectly divides the picture into two symmetrical halves.
8. Have students draw a line of symmetry through the star on their worksheet. They can use their mirrors to help. Make sure to clarify to students that some images/objects have multiple lines of symmetry.
9. For the partial image of the face, have students use their mirrors and knowledge of symmetry to complete the picture.
10. Make **crayons** available. In the empty box, have students create their own symmetrical drawing. You could have students show the line(s) of symmetry on their own drawing, or students could swap papers to find the lines of symmetry in each other's drawings.
11. If time allows, you may want to examine some items in the classroom and play a game of "symmetrical or not?" with your students.

ACTIVITY PHOTOS:

6.3


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)

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

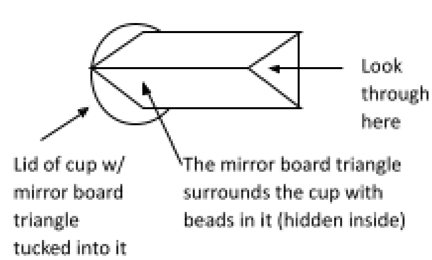
WHAT GOES HOME: Kaleidoscope

PROCEDURE:

1. Give each scientist a **mirror board and a lidded 1oz cup containing eight 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?*



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.

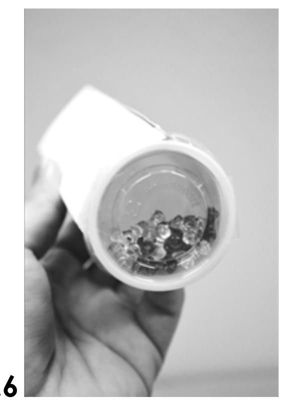
3. Have students:
    a. Fold the mirror board into equal thirds lengthwise, with the reflective side in.
    b. Tape the mirror board closed along the edge so it forms a triangular tube (Photo 6.4).
    c. Turn the 1oz cup with beads upside down so that the lid is on the bottom.
    d. Fit the triangular 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 6.5).
    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 6.6).

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.

ACTIVITY PHOTOS:

6.4 

6.5 

6.6 

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 transparent		X	
Crayons, black	Class 7		
Crayons, blue	Class 7		
Crayons, box	Class 7		
Crayons, red	Class 7		
Cups, 1oz		X	
Lab notebooks	Class 7		
Lids, 1oz		X	
Markers, black washable			X
Mirror boards		X	
Mirrors, 2x3in		X	
Pencils	Class 7		
Scissors (site provides)			X
Tape, Scotch rolls	Class 8		
Worksheets			
Symmetrical		X	

GRAND TOTAL OF WHAT GOES HOME: Kaleidoscope, symmetrical worksheet, 2x3in mirror.

CLASS 7: CURIOUS COLORS

Supplies (in class bags)	#
Beads, UV color changing	16
Color tablets, blue	4
Color tablets, red	4
Color tablets, yellow	4
Crayons, blue	4
Crayons, box	4
Crayons, red	4
Cups, dixie	12
Lab notebooks	16
LED light blue	4
LED light green	4
LED light white	4
Newspaper bundle - *in kit box*	1
Paper towels, roll - *in kit box*	1
Pencils	16
Pipe cleaners	16
Pipettes	48
Pitcher - *in kit box*	1
Plates, 9in	4
Polarized filter	1
Scissors (site provides)	16
Trays, 12 well	16
Water	
Wooden tops	16
Worksheets (in envelope)	**#**
Circle templates	16
Color wheel sheet	2
Electromagnetic spectrum	1
Glow paper (1/2 sheet)	4
Paper, white full sheet	16

PREP STEPS:

- **Act. 2a:** Fill pitcher with water if needed
- **Act. 2b:** Fill the 12 dixie cups with water and add one color tablet to each cup.

VOCABULARY:

- **Color theory:** The study of how colors work together and how they affect our emotions and perceptions.
- **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.
- **Pipette:** A thin tube with a bulb (like an eye dropper) used to transfer small amounts of liquid.
- **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: 5 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16

BOOK RECOMMENDATION: *Color Blocked* by Ashley Sorenson

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?*

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: COLOR SPLASH

TIME: 20 Minutes

SOURCE: Steve Spangler Science

Supplies	#
Color tablets, blue	4
Color tablets, red	4
Color tablets, yellow	4
Cups, dixie	12
Newspaper, bundle	1
Paper towels, roll	1
Pipettes	48
Pitcher	1
Plates, 9in	4
Trays, 12-well	16
Water	
Worksheets	**#**
Color wheel	2
Paper, white full sheet	16

BACKGROUND:

Most people know there are primary colors (red, blue, yellow), and secondary colors (green, orange, purple), but did you know there are also tertiary *(TER-she-airy)* colors? In this activity, you can create some in your trays. Tertiary colors are formed by mixing a secondary and primary color together, then the names of the two original colors can be combined to name the new color.

Examples of tertiary colors include yellow-orange, red-orange, red-purple, blue-purple, blue-green, and yellow-green. What about brown? That's also a tertiary color! Tertiary colors can also be formed by mixing two secondary colors.

The study of how colors are mixed and work together is known as color theory. Fashion and interior designers as well as graphic and mixed media artists use color theory to trigger certain feelings or thoughts. For example, using red, green, and yellow together might remind a person of a tropical forest. Blue, gray, and white might remind someone of a cold mountain. Can you think of colors that could create a feeling or memory? (bit.ly/3M3Tnuf)

GOAL: To investigate color mixing.

WHAT GOES HOME: Pipettes, Trays, Pictures

PROCEDURE:

1. Cover desks/tables with **newspaper**.
2. Put students into four groups.
3. Give each student **three pipettes and a well tray**. Make **paper towels** available for cleaning up.
4. Give each group a **paper plate with three Dixie cups on it: one with red water, one with yellow water, and one with blue water**. (You may have prepped the cups of colored water, or you can drop the fizzing tablets in the water as students watch.) Place the paper plate with Dixie cups in the center of the group. Students can rest their pipettes on the plate when they're not using them (Photo 7.1).
5. Have students practice using one of their pipettes for one of the colors. They should draw up some of the colored water and release it back into the cup. They're ready to move on when they can release one or two drops at a time.
6. Using a different pipette for each color, have students place a generous squirt or two of red in one well, blue in another, and yellow in a third. This is so they can use the colors from their well instead of reaching for the Dixie cups. It is important that students don't mix up their pipettes as this could affect the colors created (Photo 7.2).
7. Refer students to the **Color Wheel worksheets** to remind them of the colors. It may help to leave them on tables while the scientists are working.
8. Have students use their three primary colors to create green, orange, and purple. Encourage them to start by using similar amounts of the two colors they're mixing (e.g., three drops of red and three drops of blue).

   Discussion Prompts:

   - *What do you notice about the colors you created?*
   - *What else can we do with these colors?*
   - *How many different colors can we make?*

9. After students have mixed their secondary colors, encourage them to start mixing different amounts of two colors together to see if they get different results.
10. Give students a goal: to fill their well trays with a different color in each well.
11. Pass out pieces of **white paper**. The class can experiment with dripping different colors onto the paper to make a picture.
11. Allow students time to keep mixing colors in different amounts to make as many different colors as possible. Make sure students pay attention to how many drops of each color they add to mix a new color. This way, they can try different variations to make new shades of the same color. Let students make their own discoveries.

12. After students fill up each of the wells, ask them to pick their favorite color they created and remember which colors they mixed to create it. They can think up a name for their color as well.
13. Have students carefully dump their colors in the sink and rinse out their trays. If you don't have a sink in the classroom, have them empty their trays carefully into the pitcher (or you may want to do it instead), then wipe the trays with newspaper or paper towels.
14. Set pictures aside to dry during the rest of class.

ACTIVITY PHOTOS:

7.1 

7.2 

ACTIVITY 3: RAINBOW SPINNERS

TIME: 10 Minutes

SOURCE: bit.ly/3OW5ATM

Supplies	#
Crayons, blue	4
Crayons, box	4
Crayons, red	4
Pencils	16
Scissors (site provides)	16
Wooden tops	16
Worksheets	**#**
Color wheel sheet	2
Circle templates	16

BACKGROUND:

White light is made of all the colors of the rainbow, as we learned in Class 5, but this time we are going to blend all the colors together to make white, instead of splitting white light to show the rainbow. This activity works thanks to our old friend, persistence of vision - the same thing that let us see the fish in the fishbowl for the Fishbowl Thaumatrope in Class 3. When spinning a rainbow disc our persistence of vision causes us to see all the colors together at once, making the spinning disc appear white(ish). (bit.ly/3sBaH2U)

GOAL: To demonstrate that when rainbow colors are mixed they look like white because of persistence of vision.

WHAT GOES HOME: Wooden top with paper disk

PROCEDURE:

1. Remind your class that you have used materials like prisms to split white light into a rainbow of colors.

   Discussion Prompts:

   - *What happened when we used the Benham's disks? What did we see?*
   - *Did we do any other experiments where something looked different than expected?*

2. Have scientists sit in groups of four. Pass out **crayons** to each group.
3. Give each scientist a **circle template worksheet** (Photo 7.3). Have the **Color wheel sheet** available for reference.
4. Have everyone color their rainbow circles in the following manner: red, orange, yellow, green, blue, purple using crayons (Photo 7.4).
5. Have students cut out their circles with **scissors**.
6. Pass out a **pencil and a wooden top** to each scientist.
7. Using the tip of a pencil, poke a hole in the center of the rainbow-colored paper (Photo 7.5).
8. Press the rainbow paper onto the wooden top using the hole started by the pencil (Photo 7.6).

TIP: if needed, tape the paper to the wooden top using a loop of tape between the circle template and the top.

   Discussion Prompts:

   - *What do you think will happen when we spin this top?*
   - *Will the colors all be visible?*

9. Spin the wooden top. When spun fast enough, the colors will all blend together to look white, or close to it (Photo 7.7)!

   Discussion Prompts:

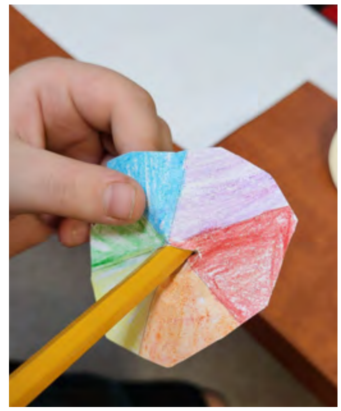
   - *What happened? Did the top look colorful? Or closer to white?*

- *Why do you think this happened?*
- *What other experiment did we do that was like this one? How is this different?*

ACTIVITY PHOTOS:

7.3 

7.4 

7.5 

7.6 

7.7 

ACTIVITY 4: COLOR-CHANGING BEADS

TIME: 10 Minutes

SOURCE: stanford.io/3wAzkw1

Supplies	#
Beads (UV, color-changing)	16
Pipe Cleaners	16
Polarized Filter (1.5inx2.5in)	1
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 (UV) 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)

GOAL: To learn about ultraviolet light using UV-sensitive beads

WHAT GOES HOME: Pipe cleaner with bead

PROCEDURE:

1. Show students the **Electromagnetic Spectrum** worksheet and discuss different types of light. If the scientists don't notice it, be sure to point out ultraviolet light.

   Discussion Prompts:

   - *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?*

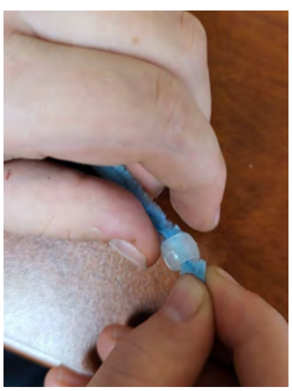
2. Give each student a **UV color-changing bead and a pipe cleaner**.
3. Have your scientists thread one bead onto the pipe cleaner and loop the pipe cleaner to lock the bead in place (Pictures 7.8 - 7.9). The pipe cleaner loop can be larger than the one pictured below.
4. Take the students outside if 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 hypothesis about what will happen once we expose the beads to light.
6. Expose their beads to the sun until the beads change colors (Picture 7.10).

Discussion Prompts:

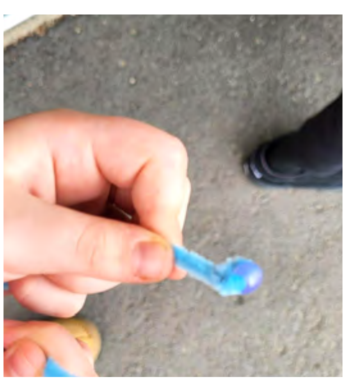
- *What happened when the beads were exposed to the sun? How is that similar to what happens when people are exposed to too much sun?*
- *Would this experiment be different on a cloudy day vs sunny day? Why/why not?*
- *If UV can cause sunburned skin, can it also cause sunburned eyes? (Yes!)*
- *What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

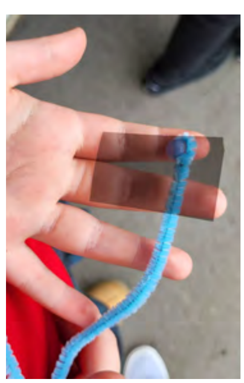
7. Discuss what's happening and how UV light affects the beads (and also our skin!) even though we can't see it.
8. Show students the **polarized filter** and tell them that it blocks out about half of all light rays passing through it.
9. Hold your pipe cleaner with a bead on your hand and cover it with the filter. The rest of the class will expose their beads with no filter (Picture 7.11).
10. Expose the beads to outdoor light at the same time.
11. After one minute, remove the polarized filter and quickly ask students to compare the brightness of the beads.

ACTIVITY PHOTOS:

7.8 

7.9 

7.10 

7.11 

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:

Many things can glow using different techniques. Highlighters can take in UV light and release it as a bright neon glow: fluorescence. In this activity, you will learn about a similar 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*)*

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 give every group member a small piece

PROCEDURE:

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 hypothesize 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.

   Discussion Prompts:

   - *How are glow-in-the-dark items different from the UV beads?*
   - *What happened to your paper?*
   - *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.

   Discussion Prompts:

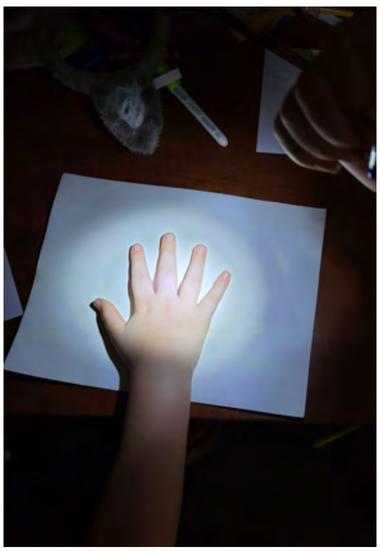
   - *Why do you think we are putting a hand over part of the Glow Paper?*
   - *How do you think the area blocked by the hand will compare to the area we will shine the lights on? Will it be brighter or darker?*
   - *What happened? Why?*

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 (Picture 7.12).
10. While the above step is happening, ask students to make another hypothesis 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 (Picture 7.13).
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 (Picture 7.14). This is phosphorescence in action!
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. <u>If desired, students can test some additional variables:</u> 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 (Picture 7.15)!

ACTIVITY PHOTOS: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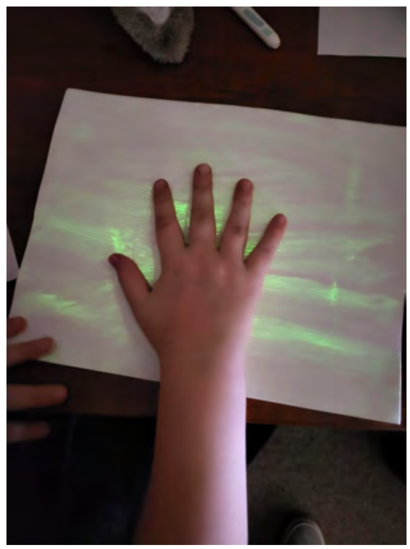
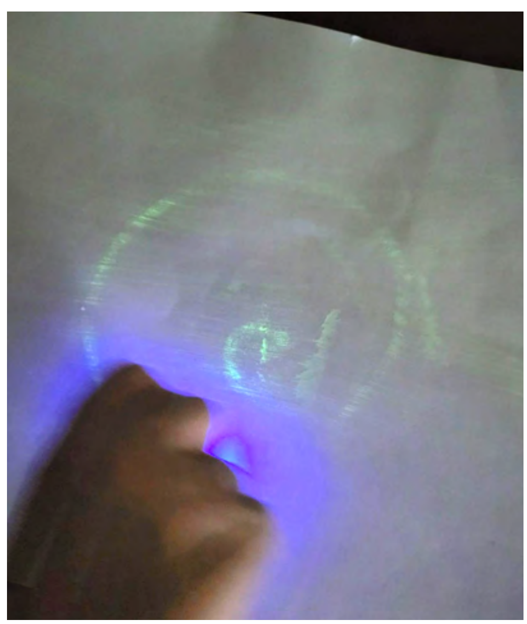

7.13


7.14


7.15

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 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?*

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 K-2)

Class 7: Curious Colors

Supplies	**Move to:**	**Send home**	**Save for SUN, recycle, or discard**
Beads, UV color changing		X	
Color tablets, blue			X
Color tablets, red			X
Color tablets, yellow			X
Crayons, blue	Class 8		
Crayons, box	Class 8		
Crayons, red	Class 8		
Cups, dixie			X
Lab notebooks	Class 8		
LED lights, blue	Class 8		
LED lights, green	Class 8		
LED lights, white	Class 8		
Newspaper			X
Paper towels			X
Pencils	Class 8		
Pipe cleaners		X	
Pipettes		X	
Pitcher			X
Plates, 9in			X
Polarized filters, 1.5x2.5in			X
Scissors (site provides)			X
Trays, 12 well		X	
Wooden tops		X	
Water			X
Worksheets			
Circle templates		X	
Color wheel sheet			X
Electromagnetic spectrum sheet			X
Glow paper		X	
Paper, white full sheet		X	

GRAND TOTAL OF WHAT GOES HOME: UV beads on pipe cleaners, Glow paper, pipettes, 12-well trays, pictures, wooden tops with rainbow spinner color wheel.

CLASS 8: OUTSTANDING OPTICS

Supplies (in class bags)	#
Glow sticks	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
Worksheets (in envelope)	**#**
Aluminum foil squares, 4x4in	16
Paper, black cardstock	32
Parchment paper squares, 4x4in	16
Snow Goggles, 1/3 sheets	16

PREP STEPS:

None!

VOCABULARY:

- **Camera Obscura:** A darkened box with a convex lens or aperture for projecting the image of an external object onto a screen inside.
- **Chemiluminescence:** The emission of light during a chemical reaction which does not produce significant quantities of heat.

ACTIVITY 1: PAIR & SHARE

TIME: 5 Minutes

Supplies	#
Pencils	16
Lab Notebooks	16

BOOK RECOMMENDATION: *Jupiter's Adventures: My New Glasses* by Anthony Cephas

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 that glows?*
   - *Can you think of a way to reduce glare from the bright sunlight?*

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: SNOW GOGGLES

TIME: 10 Minutes

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

Supplies	#
Crayons (optional)	all
LED 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)

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)*

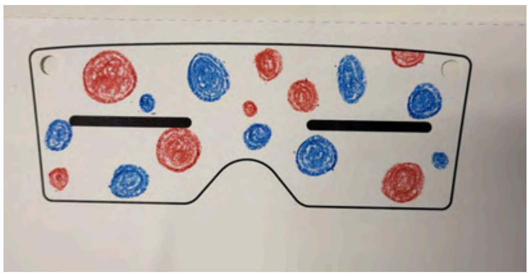
2. Pass out a **snow goggles worksheet, a 3-foot piece of yarn, and scissors** to each scientist.
3. Explain that everyone will be making a pair of snow goggles and then testing to see how they reduce glare from bright lights.
4. *Optional* Allow your scientists to decorate their glasses with **crayons** before cutting them out (Photo 8.1).
5. Have your scientists cut out the glasses along the solid outline (Photo 8.2).
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. The light holder should move the flashlight until the other student can see the glare of light on the side of their nose (Photo 8.3). 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:

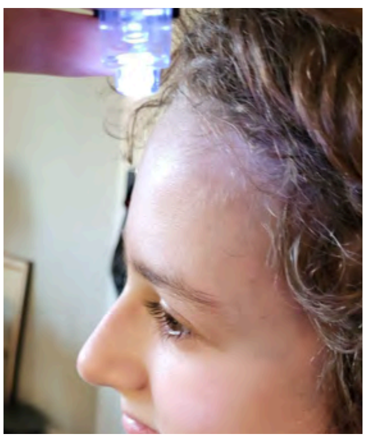
   - *Why do you think the goggles reduce glare?*
   - *Is there a way to modify the goggles to make them even more effective?*

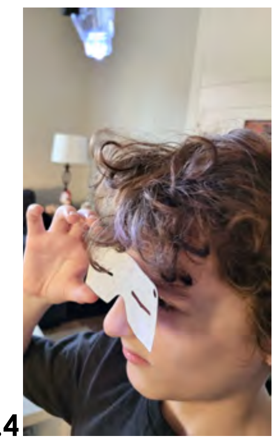
9. Thread the yarn through the holes in the top of the glasses (Photo 8.5). Scientists can help each other tie the yarn behind their heads to hold the glasses in place.

ACTIVITY PHOTOS:

8.1


8.2


8.3


8.4


8.5


ACTIVITY 3: GLOW STICKS

TIME: 5 Minutes

SOURCE: Nicole Howe, AKA Science

Supplies	#
Glow sticks	16

BACKGROUND:

A glow stick contains two different chemicals that produce a glow when they're mixed. Because the glow only lasts for as long as the chemical reaction, the glow stick makers have to keep those chemicals separate until the person who buys them wants them to glow. To keep the chemicals separated, they put one of the chemicals in a thin glass tube. When you bent the glow stick, the cracking sound you heard was the glass tube breaking in the plastic glow stick. After the glass tube cracks, it releases its chemical and it mixes with the surrounding chemical, causing a reaction. This reaction glows as long as there are chemicals left to react. Because this glow results from two chemicals reacting, it's called chemiluminescence. Unlike fluorescence and phosphorescence, the glow stick doesn't need light for energy. Instead, it uses chemicals to fuel the glow that it emits. Did you know that low temperatures slow the rate of the chemical reaction? Because of this, you can put a glow stick in the freezer to make it last longer! (bit.ly/3M36zji)

GOAL: To learn how glow sticks work.

WHAT GOES HOME: Glow sticks

PROCEDURE:

1. Give each student a **glow stick**. DO NOT have them activate it until Step #4.

   Discussion Prompts:

   - *How is this glow stick activated? Don't show me, tell me.*
   - *Why do we need to be careful with them?*

2. Give students a clue about how the glow sticks work by having them gently shake their glow sticks. They should hear a slight rattling or clicking. If they hold the stick upright (like the letter "i"), the top of the glow stick will have a pocket of air inside it. If students look very closely, they might see an almost invisible tube inside the glow stick (it might help to hold it in front of a light source). Tell them to remember that tube and to think about what might happen to it when they bend the glow stick.
3. Turn the room lights off.
4. Have students bend the glow stick until they hear a crack and carefully watch to see what's happening inside (Pictures 8.6 - 8.7).

SAFETY NOTE: Glow sticks can break open if they get mangled, and the liquid inside—while not toxic—is an irritant. Make sure kids are gentle when they bend their glow stick to activate it, and that they hold the stick at arm's length while bending it. If you don't trust your kids to do that, walk around and activate each glow stick yourself. If students get the liquid on their skin, be sure to wash with plenty of soap and water. If they somehow get liquid in their eye, be sure to flush with plenty of water.

Discussion Prompts:

- *What uses do glow sticks have?*
- *What are the downsides of glow sticks?*

ACTIVITY PHOTOS:

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.

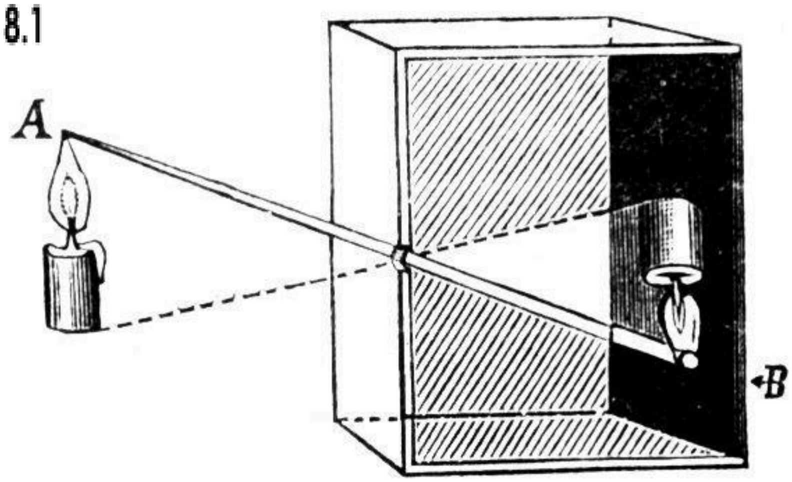
SAFETY NOTE: Do not look directly at the sun! This can damage eyes, even through the parchment paper.

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 on next page).
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).

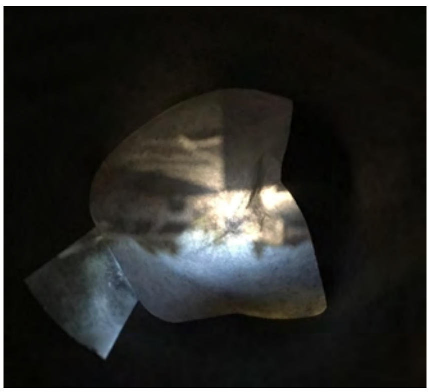
8.1



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?*

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.**

Supplies	Send home	Save for SUN, recycle, or discard
Glow sticks	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	
Worksheets		
Aluminum foil squares, 4x4in	X	
Paper, black cardstock	X	
Parchment paper squares, 4x4in	X	
Snow Goggles, 1/3 sheets	X	

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

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