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COMMUNITY RESOURCES FOR SCIENCE

BASIS Lesson Plan

Lesson Name: Lights! Colors! Vision!

Grade Level Connections:

Next Generation Science Standards: Grade 4, Physical Science (4-PS4) & Life Science (4-LS1)
FOSS Next Generation Edition: Grade 4, Physical Science, Energy

**Note to teachers: Detailed standards connections can be found at the end of this lesson plan.*

Teaser/Overview

The eye is a complicated and fascinating structure that communicates directly to the brain! We are able to see things and respond to what we see every day because of the constant communication between the eye and the brain. In this hands-on lesson, students will learn about the part of the eye known as the retina, which senses light and transmits information to our brain. Specifically, we'll explore how the rods and cones of our retina can become fatigued and how this can trick our eyes and create optical illusions. A light experiment will show students how the primary colors of light combine to form other colors and they will then use that information to make hypotheses about what optical illusions they will experience!

Lesson Objectives

- Students will learn about the different parts of the eye, focused mainly on the retina and how is transmits information to the brain
- Students will understand the importance of light to form an image and distinguish between colors.
- Students will make hypotheses about what color an after image will be based on their prior knowledge about cones and light color combinations.

Vocabulary Words

- **Retina:** a layer at the back of the eye that senses light and transmits information to the brain
- **Rod:** a light-sensitive cell in the retina that is responsible for night vision
- **Cone:** a light-sensitive cell in the retina that is responsible for color vision

- **Fatigue:** tired or worn out; your rods and cones can experience this if you stare at a bright light (rods) or if you stare at one specific color (cones)
- **Hypothesis:** a guess based on things you already know
- **Optical Illusion:** something we see that appears to be different from reality
- **After Image:** an image that your eye sees, even after that image is no longer there

Materials

Scientist Volunteers will bring:

Lantern (1)
Eye patches (32)
Poster/model of the human eye (1)
Worksheet on colors of light (32, enough for each student)
Crayons (32 sets with 1 red, 1 blue, 1 green, 1 yellow, 1 cyan, 1 magenta)
Flashlights (3, one with a red light, one with a green light, and one with a blue light)
Black cards with cyan triangle (12)
Black cards with yellow rectangle (12)
Black cards with magenta circle (12)

Materials teachers should provide:

Students should have pencils ready

Classroom Set-Up

We will start the lesson with a topic introduction at the white board while students are seated at their desks. Then students will rotate through three stations where they will make hypotheses and experience some optical illusions, so please divide the students into three equal-sized groups for this part of the lesson. Students will then return to their desks for a wrap-up discussion. We will provide a worksheet to guide students through the hands-on activities so they will need a pencil or other writing utensil. We would like to project a few images at the end of classIt would be helpful if students wear name tags during the lesson.

Classroom Visit

1. Introduction (15 minutes)

***For this particular lesson, pass out eye patches and turn off the lights for the beginning introduction. Have a lantern and instruct students to focus on the lantern and the speaker with the*

*lantern. As each volunteer introduces herself/himself, the lantern should follow so the students can see them with their one uncovered eye.***

Role Model Introduction:
Being a role model for students is an important part of being a BASIS volunteer. Begin your lesson by introducing yourselves! Every team member should take a moment to explain who they are and what they study/do as a scientist. A bonus will be to tell your "story," as if giving an elevator pitch to 9-year-olds: Why did you become a scientist? What made you interested in your topic? Why should students relate to you, or be interested in you? Feel free to draft a script of what you will say, here. And remember, you can also weave your story throughout your lesson through examples from your own life, and/or return to it with Q&A at the end.

Topic Introduction:
After you introduce yourselves as role models, take some time to introduce the topic of this lesson: the retina and its role in transmitting light information to the brain. It may be helpful to keep the suggested take-away in the back of your mind throughout the lesson: **Our retinas are composed of rods and cones. We can use information about our cones to make predictions about what optical illusions we can expect to see.**

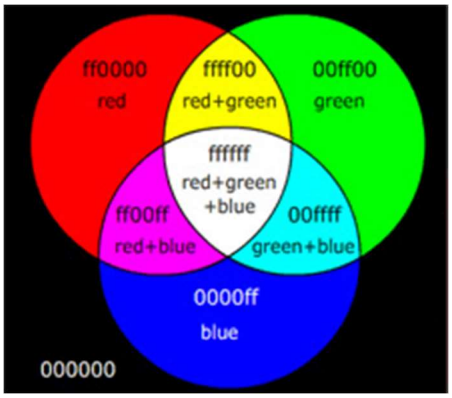
Your topic introduction should follow the outline below. As much as possible, try to frame this information as questions posed to the class, rather than as a lecture. This helps activate students' prior knowledge and facilitate student-guided conversation.

- Today we are going to talk about our eyes and vision! Turn to the person next to you and discuss everything you know about eyes right now. [Think-Pair-Share]
- Have students share ideas and make sure to gather their ideas into a list on the board.
- This is a great list of things we already know about eyes to get us started! Today, we're going to focus on the part of the eye known as the **retina** [define, write on board]
- The retina is located at the very back of our eyeball and it has specific cells called **rods** and **cones** that are able to take information from light and then send it to our brain so that we can process it and understand it.
- You've all been patient pirates, sitting with your eye patches this whole time. Does anyone know why pirates used to wear eye patches? [Students may suggest swordfights, missing an eye, etc.] While a few pirates may have worn eye patches because they were missing an eye, there may be a different reason why they wore them. Pirates were often on ships and if you've ever been on a ship before you know that there is the deck of the ship that's really bright during the day, but then if you go below deck, it can be really dark.
- Some of the cells on our retina help us to see when it's dark outside, but if those cells are exposed to lots of light, they get tired and stop working. Let's see if our experiment worked. [Turn off the flashlight]
- Okay, everyone open your eyes! Now cover your right eye and then switch to your left. Do you notice any difference? [Students should be able to see more clearly with the eye that previously had the eye patch over it]

- This happens because the cells in the back of our eye that were staring at the light became really tired. This is called **fatigue** [Define, write on board]
- We just created fatigue for our rods, the cells responsible for night vision.
- **Cones** are responsible for color vision. Do you think we can fatigue those too?
- Let's do some more science activities and see for ourselves!

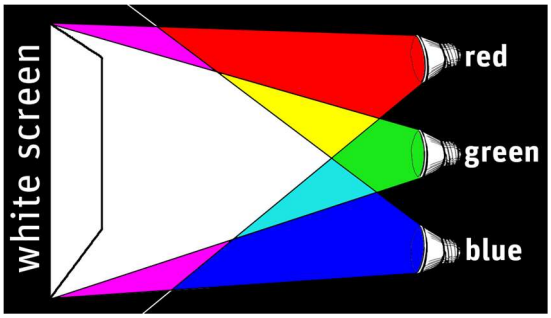
2. Learning Experience (35 minutes)

Students will work in pairs. Remember that these activities are designed to address the take-away in a particular way: **Our retinas are composed of rods and cones. We can use information about our cones to make predictions about what optical illusions we can expect to see.**



Activity 1: Light Color Combination (10 minutes)

1. Pass out worksheets and crayons to students. Have them put their name at the top and follow along and fill in the above image with the correct colors as you proceed through this activity.
2. Who here has painted before? Can you combine colors of paint to make other colors? [Yes!] Light is similar because we can combine colors of light to make other colors. Let's explore how different colors of light combine in your classroom! [Turn off lights again]
3. First, we're going to think about the **cones** on our **retina** and the different colors that they can detect. We have three different types of cones in our retina – Red, Green, and Blue [Shine red flashlight on top left of the board, green flashlight on top right of the board, and blue flashlight on bottom of the board. Keep them separated for now.] These are our three primary light colors. Go ahead and color these in on your worksheet. [Turn on lights so students can color these in]



https://www.exploratorium.edu/snacks/colored-shadows

4. We can combine these light colors together. [Turn off lights again] Let's first combine red + green [= yellow]. Then go through red + blue [= magenta] and blue + green [= cyan]. Turn back on lights and have students complete their diagram.
5. One final time turn off the lights. What do you think will happen when we combine all three? [Combine and show students white light]

Activity 2: Optical Illusions and After Images (15-20 minutes)

https://faculty.washington.edu/chudler/chvision.html

http://www.animations.physics.unsw.edu.au/jw/light/complementary-colours.htm

For the following activity, students will be divided into three equally sized groups that will rotate through three stations. The instructions should be discussed with each student group initially at the first station and then re-emphasized in the following two stations.

Station 1: Cyan (Blue & Green) Fatigue → Red After Image
Station 2: Yellow (Red & Green) Fatigue → Blue After Image
Station 3: Magenta (Red & Blue) Fatigue → Green After Image

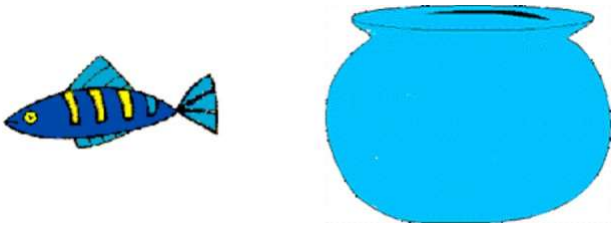
1. Now that you're super vision scientists and know how our cones perceive light, we can make hypotheses about what optical illusions we might see based on the fatigue we talked about earlier! We're going to make one of your cones super tired (or fatigued) and that's going to trick your brain into seeing different colors that aren't really there!
2. Let's work through one together first. In a moment, we're going to pass out a cyan triangle on a black background. You're going to have to stare at it for 30 seconds to trick your eyes. Then you'll flip the page over to this white sheet of paper, and blink a few times. You'll see something called an **after image**. An image that isn't really there. What color do you think it will be? [Guide students to the answer here, referring back to their image that they previously colored in]
3. Write down your hypothesis for our first image. Now let's test it!
4. Pass out optical illusion sheets for (Station 1, Station 2, Station 3). Once images are passed out, instruct students to begin all at the same time and then have a timer. Wait 30 seconds. Emphasize to students that they can only trick their eyes if they ONLY stare at the triangle!

5. Wait 30 seconds. Then tell students to immediately flip their page over and stare at the white paper. Blink a few times. Do they see anything? What color is it? [Students should see a RED triangle]
6. Repeat the experiment to see if it happens again (and in case any students didn't stare at the triangle for long enough.
7. Did the data the students found support or reject their hypothesis? Why or why not?
8. Have students rotate through all stations.

Activity 3: Optical Illusions and After Images, Review

1. Have students return to their desks.
2. Now that you've all experienced cone fatigue in your eyes and after images, we're going to do one final activity as a class.
3. On a document cam or project, show class the "Bird and the cage". Can anyone tell me how you could trick your eyes into putting the bird in the cage? [Gather responses from students, emphasize using the vocab words from earlier in the lesson].
4. Will the bird change color when we put it in the cage? If so, what color will the parrot be? What color will the cardinal be?

5. Have students see if they can put at least one of the birds in the cage by tricking their eyes!
6. If time allows, have students predict what color the fish will be when they put it in the bowl:



3. Wrap Up: Review and Discuss the Learning Experience (5 minutes)

It's important to leave time to **review** and **discuss** the learning experience at the end of the lesson. This might take the form of discussing conclusions from an experiment; or review of the take-away of the lesson

- Review the terms retina, rods, and cones
- What are the primary colors of light that we can detect with our eyes? What are some of the other combinations?
- Discuss what the students noticed when we tried to fatigue the different cells in our eyes.

- Prompt students to think about what other questions they have about vision and how scientists might figure out the answers to those questions.

4. Connections & Close (5 minutes)

Close:

- Ask students if they have any questions about science, being a scientist, or about becoming a scientist
- Close with a good bye and a thank you, and encourage the kids to keep thinking about ways they use their vision every day!

Follow Up: After the Presentation

Teachers who wish to extend the impact of this lesson may find the following CRS web pages useful:

- http://www.crscience.org/educators/helpfulreports
- http://www.crscience.org/educators/treasuretrove

Standards Connections

NGSS:

- Connections by topic
  - Life Science: 4. Structure and Function
  - Physical Science: 4. Waves: Light and Sound
- Connections by disciplinary core ideas
  - Life Science: 4-LS1. From Molecules to Organisms: Structure and Processes
  - Physical Science: 4-PS4. Waves and their Applications in Technologies and Information Transfer
- Connections by scientific & engineering practices
  - 4. Analyzing and interpreting data
  - 6. Constructing explanations and designing solutions
- Connections by crosscutting concepts
  - 2. Cause and Effect: Mechanism and explanation
  - 6. Structure and Function: Determine properties of things
- Connections by performance expectation
  - 4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
  - 4-PS4-2. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.