

2013 NATURE Summer Camp

Colors & Light



Description:

Did you ever wonder why you see the colors, or if other animals see the same colors that you see? You might not know it, but light bounces off of things around us. It is that light that gives us the ability to see. When the light enters our eyes, special cells tell our brains about the light. These cells are called photoreceptors. Light is made of little bits called photons. When the sun shines, trillions and trillions of these little bits of light fall on the earth. The photons bounce off of almost everything and some of them enter our eyes. Those bits that enter our eyes allow us to see. So, where does the color come from?

Starting in the 1600s with Sir Isaac Newton, scientists have believed that there are different kinds of photons. Different types give rise to our sense of colors. The different photons are said to have different wavelengths. Sunlight contains all the different wavelengths of photons. The visible wavelength colors can be seen when you look at a rainbow. Raindrops acting as natural prisms produce the colors.

We have two main types of photoreceptors called rods and cones. They are called rods and cones because of their shapes. These cells are located in a layer at the back of the eye called the retina. Rods are used to see in very dim light and only show the world to us in black and white. This is why you see only black and white when you are outside in the evening or in a dimly lit room. The other type of photoreceptors, the cones, allow us to see colors. They are not as sensitive as the rods so they only work in bright light. There are three types of cones, one for each of the three main colors we see, red, green and blue.

Color theory is a vast and complicated sphere of knowledge. It consists of different scientific elements, such as: optics, spectroscopy, human anatomy and physiology, psychology, art history and theory, philosophy, ethics, architecture theory, design and many other applied sciences.

In today's lesson, you will examine the relationship between color and light. You will find out that mixing colors isn't as straight forward as it sounds. You will understand the answer to a question that most people, probably including your parents, don't know the answer to. And, you will even discover a connection between colors and climate change!

Objectives:

- To learn about the electromagnetic spectrum
- To understand how additive and subtractive color mixing are different
- To discover the relationships between colors and temperature
- To become familiar with applications of chromatography
- To build and use a simple spectroscope
- To answer the question “Why is the sky blue?”

Education Standards:

11-12.2.2 Select and use appropriate instruments, measuring tools, and units of measure to improve scientific investigations

11-12.2.4 Formulate and revise explanations based upon scientific knowledge and experimental data

11-12.2.5 Use technology and mathematics to improve investigations and communications

11-12.3.11 Explain how energy is related to physical changes of matter (e.g., phase changes, temperature changes)

11-12.6.1 Select and use appropriate technologies, tools, and techniques to solve a problem (e.g., computer-assisted tools, Internet, research skills, CBL, graphing calculators)

11-12.6.2 Identify examples of how new technologies advance science

Schedule:

9:00 – 9:30	Cultural Connection
9:30 – 10:20	Activity 1 (Mixing Colors)
10:20 – 10:35	PP Instruct #1
10:35 – 11:00	Activities 2 & 3 (Wave Walk & Make Your Own Prism)
11:00 – 11:15	PP Instruct #2
11:15 – 11:40	Activities 4-6 (Hexadecimal Color Codes, Mixing Colors Applet, Newton’s Disc Online)
11:40 – 12:00	Activities 7 & 8 (Why Is the Sky Blue? Why Is the Sun Yellow?, The Color of Clouds)
12:00 – 12:45	LUNCH
12:45 – 1:05	Activity 9 (Albedo Effect)
1:05 – 1:15	PP Instruct #3
1:15 – 2:30	Activities 10-12 (Color and Heat Absorption, Chromatography, Spectroscope)
2:30 – 3:00	Session Wrap-up

OPENING QUESTIONS

Why is the sky blue? _____

Why is the sun yellow? _____

Activity 1: Mixing Colors

PART A

Watch the demonstration and answer the following questions when instructed.

Colors to be mixed	Color you think mixture will be	Actual color of mixture
1. BLUE and RED		
2. BLUE and GREEN		
3. RED and GREEN		
4. BLUE and RED		
5. BLUE and GREEN		
6. RED and GREEN		

PART B

In this activity, you will replicate Isaac Newton's experiment with a colored disc. In your group of four people, each member should make a different version from the choices below. When completed, spin your disc as quickly as possible and record the color you see, along with the color for each other member in your group.

Materials

- CD-R
- marble
- printer paper



- scissors
- markers (or crayons, or colored pencils)
- hot glue gun with glue
- protractor



Procedure (see diagrams above):

1. Trace CD on white paper (also trace the center hole).
2. Use protractor to divide the circle into appropriate sectors for your pattern.
3. Color the sectors with the correct colors.
4. Cut the paper so it is the size of the CD. Also cut out the center hole.
5. Glue or tape the colored cutout on to the CD.
6. Hot glue the marble to the central hole. Glue it from the top (colored side).

When the glue is dry, the marble will barely stick out of the bottom. Spin the disc quickly and record what color(s) you see. Don't stare too closely, just get a general sense of color.

PATTERN ON DISC	COLOR(S) YOU SEE
ROY G BIV – even distribution	
3 sectors – RGB	
12 sectors – RGB repeated	
ROY G BIV – uneven distribution	

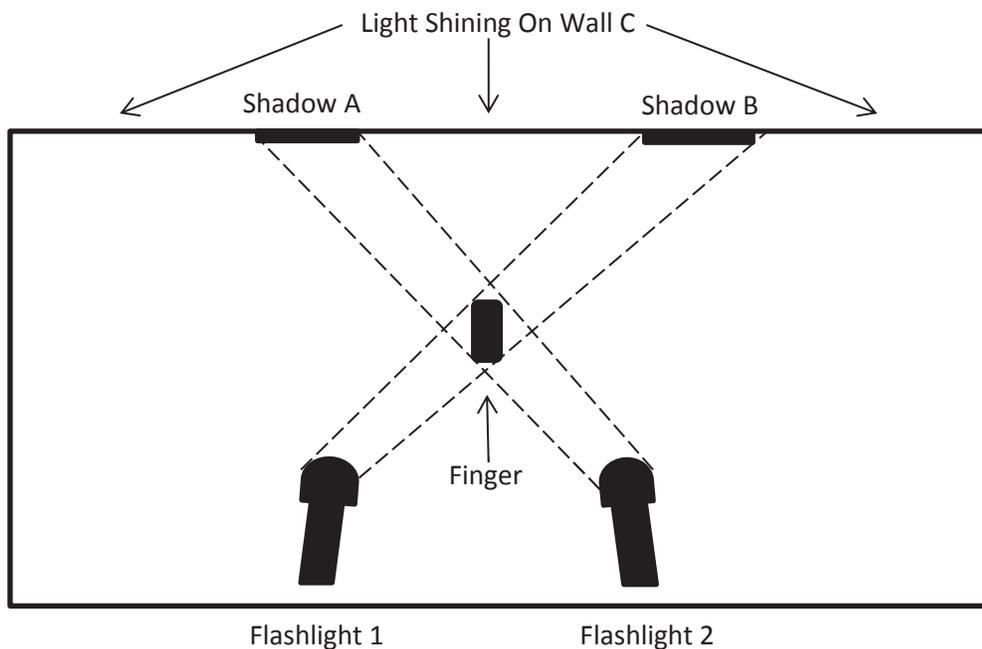
PART C

In this activity, you will experiment with your group members and combine three colors of light to see how they mix. You will also examine how shadows behave when using combinations of these colors.

Fill in this chart before doing the experiment. If you don't know the answer – take a guess!

When mixing the colors of light ...	I think the resulting color of light will be ...
BLUE and RED	
BLUE and GREEN	
RED and GREEN	
RED and GREEN and BLUE	

In the next chart, you will be guessing what color shadows will be cast when two colored flashlights shine on an object (like someone's finger). There will be two shadows (A and B), and the rest of the wall that is illuminated by the combination of the two lights (C). Refer to the diagram below for a reference on the shadow questions.



When the two flashlight colors are ...	I think the color of the shadows and remaining wall will be ...		
	A	B	C
BLUE and RED			
BLUE and GREEN			
RED and GREEN			

Materials

- 3 flashlights
- RGB colored gels
- projector screen (or white paper)
- tape

Procedure:

1. It is best to use a projector screen as your wall. If one isn't available, tape white paper to a wall or something so that it stands upright. (If the wall is white you do not need to use the paper.)
2. Tape a colored gel to each of the three flashlights.
3. Three members of the group will each hold one of the gel-colored flashlights.
4. Turn the lights off. You need to be in a dark space to see the results.
5. Shine the lights to make the combinations in the chart below and fill in the answers.
6. The fourth member of the group will make the shadows when necessary. Use a finger or pencil, or any other appropriate object, to make the shadows.

When mixing the colors of light ...	The resulting color of light is ...
BLUE and RED	
BLUE and GREEN	
RED and GREEN	
RED and GREEN and BLUE	

When the two flashlight colors are ...	The color of the shadows and remaining wall are ...		
	A	B	C
BLUE and RED			
BLUE and GREEN			
RED and GREEN			

Activity 2: Wave Walk

In this activity you will visualize the difference between normal and laser light. By walking in different patterns, students will simulate light of different wavelengths as well as the difference between coherent and incoherent light.

Materials

- Construction paper for ROY G BIV

Procedure:

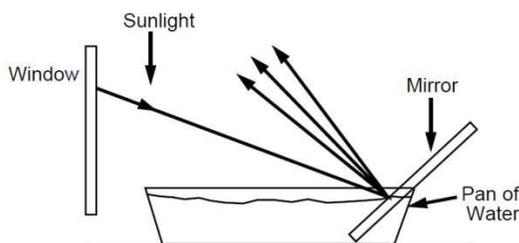
Students will be required to represent different wavelengths of the spectrum by holding a colored piece of paper corresponding to the color each is assigned, and then walking according to the teacher's instructions.

Activity 3: Make Your Own Prism

In this activity, you will create a simple prism and see if you can separate white light into the colors of the spectrum.

Materials

- pan
- small flat mirror
- light source (sun, flashlight,...)



Procedure:

1. Fill the pan with water so that it is almost to the top.
2. Lay the mirror in the pan and against its side as in the diagram above.
3. Set the apparatus by a sunlit window. If that is unavailable, use a flashlight.

You may have to move it around a bit and try some different angles, but you should eventually see a rainbow of colors reflect on the wall or ceiling. Make adjustments until you can see the colors vividly.

List the order in which you see the rainbow of colors. _____

Activity 4: Hexadecimal Color Codes

In this activity, the student will learn how to choose and manipulate the millions of color combinations available on a computer screen.

Materials

- a computer with internet access and ColorPic installed

Convert the following hexadecimal numbers to their equivalent decimal numbers:

Hexadecimal	A3	24	8F
Decimal			

Procedure:

1. Open the program ColorPic.
2. In the third section (Color), type the hexadecimal number A3248F in the box after the # sign. You might have to click on a random color in the Mixer section before it will allow you to type in your hexadecimal code.
3. Notice the color in the rectangle of the Color section. It should be a purple-ish color.
4. Look at the numbers in the Red, Grn, and Blue boxes in the Mixer section. Do they match your numbers in the table you completed above? They should!
5. Now open a blank Word document.
6. Insert a shape – make it a nice large rectangle.
7. Double click the blue rectangle you just created and go up to Shape Fill and choose More Fill Colors.
8. Select the Custom tab and enter your Red, Green, and Blue numbers in the corresponding boxes then click OK.
9. You should be staring at the exact same color as is displayed in ColorPic.
10. Now click on the upper border of the ColorPic program (so you are back in that program).
11. Click CTRL + G.

12. Move your mouse around and you will see the locations zoomed in on the Magnify section of ColorPic. You will also see the number values changing whenever you hover over different colors.
13. Hover the mouse over the rectangle you created in Word. The numbers should be the same as you originally had.

Activity 5: Mixing Colors Applet

In this activity, you will get a better look at the results of mixing two or more of the primary colors of light together.

Materials:

- a computer with internet access

Procedure:

1. Go to the following website. <http://lutherolson.weebly.com/mix-colors.html>
2. In case your flashlight activity didn't go too well, this applet will allow you to see how the three primary colors of light mix together.
3. Slide the colors around to mix them together.
4. You can hover the mouse over the color sections and it will tell you the RGB components as we just saw in the hexadecimal activity.
5. You can change the numbers in the RGB boxes to see how different shades mix.
6. To get back to the full values, enter 255. If you do not want a certain color at all, enter a zero in its box.

Now, complete this table again.

When mixing the colors of light ...	The resulting color of light is ...
BLUE and RED	
BLUE and GREEN	
RED and GREEN	
RED and GREEN and BLUE	

Activity 6: Newton's Disc Online

In this activity, you will get a better look at what should happen when you spin your Newton's Disc from Activity 1 Part B.

Materials

- a computer with internet access

Procedure:

1. Go to the following website. <http://lutherolson.weebly.com/newtons-disc.html>.
2. Click on the button to take you to the Flash website.
3. Spin the disc and observe the color at full speed.

The color of the disc at full speed is _____.

Activity 7: Why Is The Sky Blue? Why Is The Sun Yellow?

In this activity, you will discover why the sky is blue! And for a bonus, you will see why the sun is yellow.

Materials

- clear cup
- powdered milk
- stirring stick
- flashlight

Procedure:

1. Fill the cup with water.
2. Put a pinch (not too much) of powdered milk into the water.
3. Stir the mixture
4. Now shine the flashlight through the back end of the cup.

What color is the water? _____

What color is the light shining through the water? _____

Sunlight reaches Earth's atmosphere and is scattered in all directions by all the gases and particles in the air. Blue light is scattered in all directions by the tiny molecules of air in Earth's atmosphere. Blue is scattered more than other colors because it travels as shorter, smaller waves. This is why we see a blue sky most of the time.

The powdered milk in the water acted in a similar fashion to the light passing through it. That is why the water should have had a blue-ish hue. So why does the white light from the sun (or the flashlight in our experiment) look yellow?

Activity 8: The Color of Clouds

In this activity, you will learn about the color of clouds.

Materials

- 1 sheet of white construction paper
- 1 sheet of light blue construction paper
- Cloud cutouts from template sheet

Procedure:

1. Working with your group of four, each student cut out one cloud. Divide the clouds up so each numbered cloud is cut.
2. Once you have cut out your cloud, cut it in half.
3. Place one half on the white construction paper and the other half on the blue construction paper.

Do the clouds look the same shade? _____

If not, which cloud looks the “whitest”? _____

4. Repeat this with the other three students (and their clouds) in the group.

Activity 9: Albedo Effect



Which t-shirt would you prefer to wear on a hot, sunny day? Which one would help you stay cooler? Albedo is the concept of how sunlight (light energy) is absorbed or reflected and transformed into heat energy. In this lesson, you will learn which colors absorb more heat and which ones reflect it.

Materials

- 1 sheet of white construction paper
- 1 sheet of black construction paper
- scissors
- stapler or tape
- desk lamp with 150 watt bulb
- two temperature thermometers
- stopwatch or clock

Procedure:

1. Working in your group of four, cut each piece of paper in half (share with other groups).
2. Fold each $\frac{1}{2}$ sheet of white and black construction paper in half and staple or tape on three sides to form two pockets.
3. Place a thermometer inside each pocket.

4. Place both pockets below the lamp with the 150 watt bulb.
5. Record the initial temperatures in the table below before turning the lamp on.
6. Turn on the lamp and complete the table.

TIME (MINUTES)	TEMPERATURE IN BLACK POCKET	TEMPERATURE IN WHITE POCKET
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

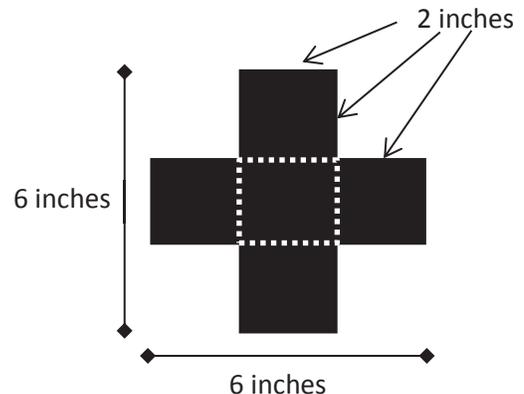
How might it be possible that the Albedo Effect could play a role in climate change? (Hint: think about the polar icecaps, their color, and what has happened to them over the past 30 or so years.)

Activity 10: Color and Heat Absorption

In this activity, you will test whether the color of a material affects how much heat it absorbs.

Materials

- 4 sheets of colored paper per group (white, yellow, red, black)
- paper towel or newspaper
- scissors (1 pair per student will speed it up)
- 4 ice cubes per group
- sunny day (or heat lamp)
- stopwatch or clock



Procedure:

1. Each group member should take one of the colored papers and make a 5-sided box according to the following specifications.
 - The dimensions of each box will be 2" x 2" x 2"
 - Measure, mark, and cut your paper according to the diagram above.
2. Fold the box and carefully tape it together.
3. Set the boxes on a paper towel or newspaper.
4. Place the boxes in an exposed, sunny place outside, or spaced evenly under a heat lamp inside.
5. Make sure the open sides of the boxes are facing out so you can see inside them.
6. Place an ice cube in each box and start the timer.
7. Observe when each ice cube finally melts and complete the table below.

COLORS	TIME TO MELT
WHITE	
YELLOW	
RED	
BLACK	

Name one practical application in the “real world” you can think of that would be supported by the results of your experiment.

Activity 11: Chromatography

In this activity, you will learn how to analyze complex mixtures by separating them into the chemicals from which they are made. This is called chromatography.

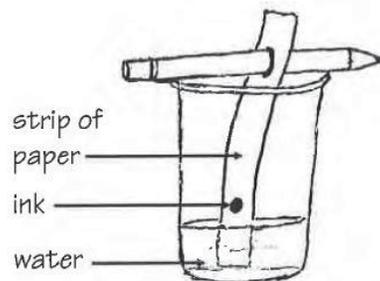
Materials

- 5 coffee filters per group
- 5 clear cups per group
- 5 markers to test
- scissors
- water
- 5 pencils, or stirring straws (something to poke through filter and rest on cup)



Procedure:

1. Working with your group of four, cut a 1-inch wide strip from the coffee filter. The strip must be long enough to just touch the bottom of the cup, and stick above the cup with enough room to poke something through to rest it on the rim of the cup and perhaps label above the rim which marker you are testing.
2. Put the strip in the cup, holding it so the bottom of the strip just touches the bottom of the cup. Poke the pencil (or whatever object you are using) through the strip, so the pencil will rest on top of the cup and the paper strip will hang in the cup, just touching the bottom.
3. Remove the strip from the cup. Put a spot of ink about $\frac{1}{4}$ inch in diameter on the strip of paper about 1 inch from the bottom end.
4. Label the very top of the strip with the marker brand you are testing.
5. Add enough water to the cup so that there is about $\frac{1}{2}$ inch of water on the bottom.
6. Place the strip in the cup with the pencil resting on the top of the cup. The spot of ink MUST be above the water level. If the water becomes colored because the spot of ink was too low, begin again.
7. Observe the water level and the spot of ink. As the water moves up the strip, the ink separates into the colors that were used to make it.
8. When the strip is wet all the way up to the pencil, remove it from the cup and allow it to dry.
9. Compare your strips to the "master strip."



Which marker was used in the crime? _____

Activity 12: Spectroscope

In this activity, you will make a simple spectroscope and use it to study the spectra from a variety of light sources.

Materials

- CD-R disc with data track
- scissors
- duct tape
- cardboard tube from paper towel roll
- aluminum foil
- hot glue gun with glue

Procedure:

1. Place one end of the cardboard tube on the CD-R so that the edge of the tube touches the outer edge of the disc. Use a marking pen to trace around the tube so as to leave a circular mark on the surface of the disc.

2. Use the scissors to cut around the circular mark on the CD-R.
3. Repeat this process to obtain additional gratings. You should be able to obtain at least four gratings from a single CD-R.
4. A clear CD is required for this activity. Apply a piece of duct tape to the label side of the CD. Pulling it up, you should notice the label comes right off. Use tape to remove all pieces.
5. Now cover one end of the cardboard tube with aluminum foil. A narrow slit, approximately 0.5 mm wide and 2 cm long should be cut in this end cap to permit light into the tube.
6. The circular grating is attached to the other end of the tube using hot glue. Before attaching the grating, make sure that the grating's grooves are parallel to the slit.
7. The finished spectroscope should look similar to the pictures.

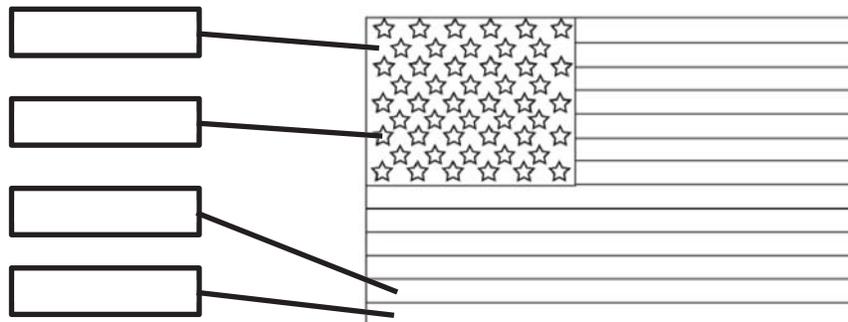


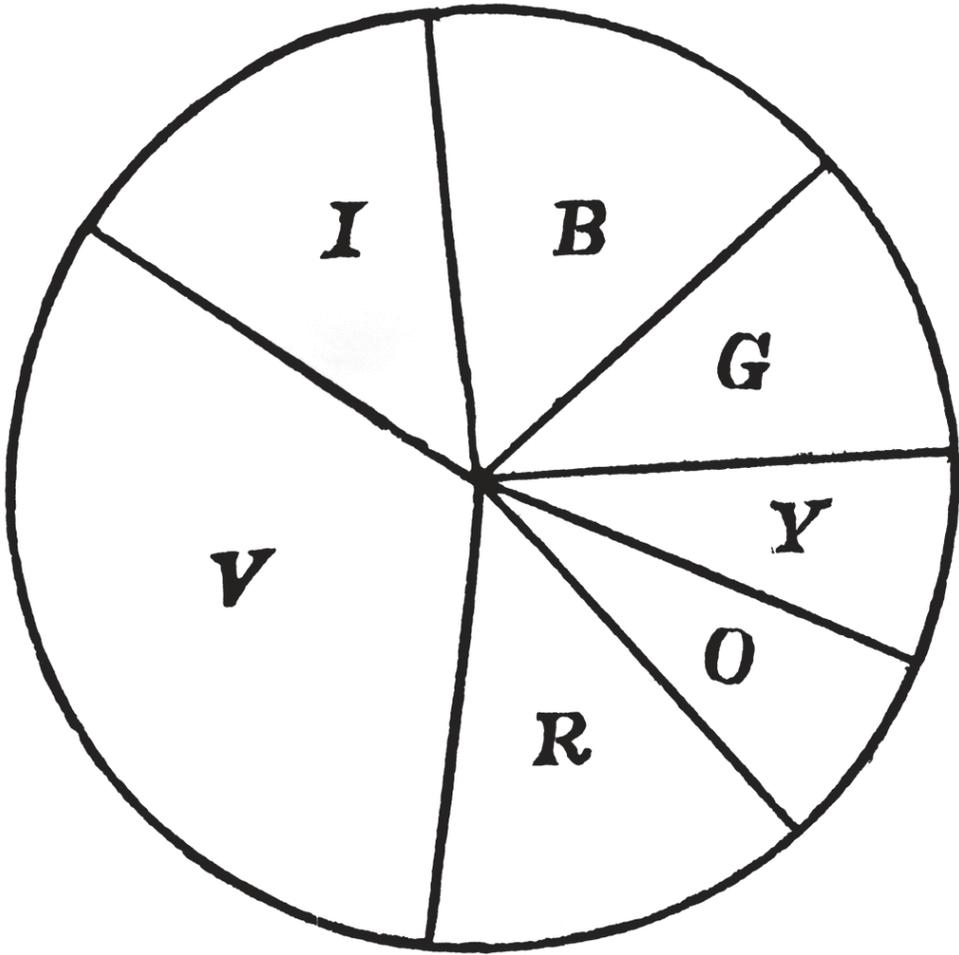
Use your spectroscope to observe at least three different light sources. Record similarities and differences among the three types of light you observed.

- 1.
- 2.
- 3.

FINAL QUESTION

If suddenly you were given a chemical that impaired the nerves in your eyes that detect red light, what color would the U.S. flag appear? Answer by labeling the diagram below.





Cloud 1



Cloud 2



Cloud 3



Cloud 4