

# You Light Up My Spectrum

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**Grades:** 5 – 8 (Upper Elementary and Middle School)

**Time Allotment:** Two or three 45 minute sessions

**Overview:** Light and Color. This lesson explores the characteristics and behaviors of visible light, including the way it affects how we see color.

**Subject Matter:** Science, Art, History

## Learning Objectives:

The student will be able to:

- Plan and conduct investigations that explore the behavior of visible light.
- Identify the characteristics of visible light, including the following vocabulary: electromagnetic spectrum, visible spectrum, light waves, refraction, reflection, opaque, transparent and translucent.
- Create an optical illusion.
- Use historical analysis skills and organize information to research people and events that contribute to understanding the concept of light.

The student will use the Internet to:

- Conduct investigations in mixing the colors of light.
- Explore the key concepts involved in understanding of light and color.
- Conduct research on people that contributed to understanding the concept of light and color.

## Standards:

The objectives listed above may be used to address the following Virginia Standards of Learning available at <http://www.pen.k12.va.us/VDOE/Superintendent/Sols/sciencesol.doc>

Grade 5: **Science 5.3** The student will investigate and understand basic characteristics of visible light and how it behaves. Key concepts include

- a) the visible spectrum and light waves;
- b) refraction of light through water and prisms;
- c) reflection of light from reflective surfaces (mirrors);
- d) opaque, transparent, and translucent; and
- e) historical contributions in understanding light.

Grade 8: **Science PS.9** The student will investigate and understand the nature and technological applications of light. Key concepts include

- a) the wave behavior of light (reflection, refraction, diffraction, and interference);
- b) images formed by lenses and mirrors; and
- c) the electromagnetic spectrum.

## Media Components:

### Video:

- United Streaming Video: <http://www.unitedstreaming.com/index.cfm>  
*Light and Color*
- Computer with Internet access

### Internet Web Sites:

- Mixing the Primary Colors of Light  
<http://www.ontariosciencecentre.ca/scizone/games/adding/default.asp> This web site allows the user to see what happens to the primary colors of light, when they are mixed together.
- Virtual Prism  
<http://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=13>  
This virtual prism allows students to demonstrate what happens when white light is sent through a prism.
- Mixing the Primary Colors of Paint  
[http://www.sanford-artedventures.com/study/g\\_primary.html](http://www.sanford-artedventures.com/study/g_primary.html) This interactive site introduces the element of color in art. Students mix the primary colors of paint (red, blue, and yellow) to make the secondary colors.
- Traditional Color Mixing in Pigment  
<http://www2.evansville.edu/studiochalkboard/c-pigmix.html>
- Characteristics of Light  
<http://t3.preservice.org/T0300715/characteristicsoflight.htm> This website explains the scientific theories of light and the scientists who made historical contributions in understanding light.
- Translucent, Transparent. Opaque  
<http://t3.preservice.org/T0300715/testyourknowledge.html>  
This website provides a visual test of students' knowledge of these concepts.

## Materials:

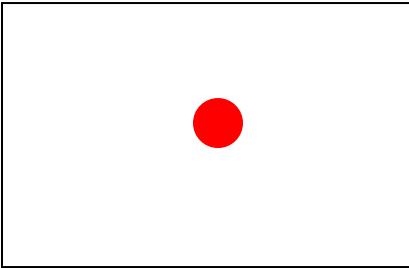
### Per Class:

- Computer lab with Internet access, or a computer station that students can rotate through to collect their information
- Computer disks for information storage

Per Student:

- 1 box of Crayola markers
- Four half-sheets of white computer paper
- 1 black Sharpie marker
- Primary Colors Worksheet
- Seeing Colors Worksheet and Color Spinners Template (for Art Extension)
- Translucent scarves in red, yellow, blue, black and white, one per student (for Movement Ed Extension)
- Transparent, Translucent, Opaque Worksheet (for Science Extension)
  
- **Prep for Teachers**
- Prior to teaching, have all Internet sites bookmarked for easy access throughout the lesson. The web sites should also be bookmarked on classroom computers for easy access by students during their individual time in the computer center, or on the computers in the lab for whole class use.
- You should preview the video clips and cue them as indicated in the Learning Activities section.
- Familiarize yourself with the lesson format and be sure to have all materials ready as listed in the materials section.
- When using media, provide students with a **FOCUS FOR MEDIA INTERACTION**, a specific task to complete and/or information to identify during or after viewing of video segments, Web sites, or other multimedia elements.

### **Introductory Activity: Setting the Stage**

1. Give each student three half-sheets of computer paper and a box of Crayola markers. On the first sheet of paper, have students draw a large solid-colored red dot in the middle. Have them place one of the other white papers next to the first one. Using a timer, have students stare at the red dot for 60 seconds. When the timer goes off the students should immediately look at the plain white piece of paper. After a moment, ask: “What color do you see?” (students will say green or bluish green). Discuss the fact that when you see light, you are actually seeing a mix of all the colors of a rainbow, because white light is made up of all the colors. Each color gives off photons, or energy. Our eyes have special receptor cells that can absorb these photons. When we see something that is red, the red color reflects off the object and the other colors are absorbed. When we looked at the red dot for so long, we overstressed our red receptors, so that when we looked at the white paper we could not see the red photons, but saw a combination of all the other colors. (green). As our eyes adjust, we begin to see the red again (or actually a combination of all the colors in the visual spectrum), so the paper appears white again.  

2. On the second piece of white paper, have the students draw one of the following: a purple rectangle, a blue square or a green triangle. Do the experiment again and have students share their results. Have them explain why they see the afterimage on the white paper. Which color receptor in their eyes was overstressed?

3. Now have the students draw a very different colored flag with familiar symbols. On the third sheet of paper, have students draw a solid orange rectangle in the upper left hand corner of the paper. Draw some green stripes to the right and underneath the orange rectangle. Using the black Sharpie pen (the permanent ink will not run into the Crayola colors), add some stars in the orange field and some black stripes between the green ones. Do the 60 second test again, but this time the



students should stare at the bottom right corner of the orange rectangle. When the timer goes off, the students should again slide their eyes immediately to the plain white paper. **Ask:**

“What do you see?” (They will be excited to see the American Flag in all it’s glory.)

**Explain:** “There are three types of color receptors in our eyes, red, green and blue. We also have black and white receptors that are more sensitive than our color receptors. That is why our color perception is poor in the dark.”

### Learning Activities

1. **CUE** the video, *Light and Color* at the beginning of the segment, showing a picture of a red apple that morphs into the face of Isaac Newton. (00:00 on video streaming counter) Provide a **Focus for Media Interaction** by saying, "This video segment will tell us some important facts about light and color. I want you to listen for the name of the person who made some important discoveries about light. See if you can also find out what he discovered." **Play** and **Pause** when the rainbow of colors is displayed with their names to the left. (00:22) **Ask:** “Who made some important discoveries about light and color and when did he make them?” (Isaac Newton, in 1665) **Ask:** “What did he discover?” (That white light entering a prism could be bent and separated into seven color groups.) **Ask:** “Can you recall the names of each of the colors?” (...red, orange, yellow, green, blue, indigo, violet) **Ask:** “Does this remind you of anything you have seen before?” (a rainbow) **Ask:** “Can you guess why a rainbow also displays this order of colors?” (...the water acts like a prism, bending and separating the white light into colors)

2. Provide a **Focus for Media Interaction** by saying, "Now listen carefully for an easy way to remember the order and names of the colors. Also be able to tell me another discovery made by Isaac Newton." **Resume** and **Pause** when the narrator says “...back to make white again.” (00:41) **Ask:** “What is an easy way to remember the order of the colors made when white light goes through a prism and separates?” (ROY G. BIV) **Ask:** “What else did Newton discover?” (...that if a second prism is used, the colors will bend, exiting the prism as white light again)

3. Provide a **Focus for Media Interaction** by saying, “Now I want you to listen for the name that is given to this collection of colors that make up white light. Also be able to tell me why they bend at different angles, and which one bends the least and which one bends the most.” **Resume** and **Pause** when the narrator says “...red bends the least because it travels faster.” (01:07) **Ask:** “What name is given to the collection of colors that make up white light?” (...The Visible Spectrum) **Ask:** “Why do the colors bend at different angles?” (...because they travel at different speeds) **Ask:** “What color bends the most?” (violet) “Why?” (...because it travels the slowest) **Ask:** “What color bends the least?” (red) “Why?” (...because it travels the fastest) **Ask:**

“When you see a rainbow do you think you will always see the colors in the same order, ROY G BIV?” (yes) “Why?” (...because each color always travels at its own speed, with red being the fastest and violet being the slowest.) Using a dry erase marker, draw the angles of the bent light to illustrate that red bends the least and violet bends the most.

4. Provide a **Focus for Media Interaction** by saying, “Let’s see if you are right about that. Also be able to tell me another important fact about light.” **Resume** and **Pause** when the narrator says “...only the visible spectrum can be seen by humans”, where the video shows the Electromagnetic Spectrum chart. (01:35)

**Ask:** “Does light travel slower through glass, water, or air?” (It travels slower through glass and water than it does through air.) **Ask:** “What is light?” (Light is a form of radiation, given off by the sun.) **Ask:** “Does anyone remember the name of the larger spectrum that the Visible Spectrum is just a small part of?” (The Electromagnetic Spectrum) **Ask:** “What part of the Electromagnetic Spectrum can be seen by humans?” (The Visible Spectrum)

5. Provide a **Focus for Media Interaction** by saying, “Now listen for the two types of radiation that are on either side of the Visual Spectrum. See if you can tell me some important facts about each type.” **Resume** and **Pause** when the narrator says, “...infrared energy is heat energy.” (02:30)

**Ask:** “What are two types of radiation that are given off by the sun that we cannot see?” (ultraviolet and infrared radiation) **Ask:** “Where is ultraviolet radiation found on the Electromagnetic Spectrum?” (just to the right of violet on the visible spectrum) **Ask:** “What is important for us to know about ultraviolet rays that could affect our health?” (you cannot see ultraviolet rays, but they can cause sunburn and skin cancer) **Ask:** “Where is infrared radiation found on the Electromagnetic Spectrum?” (to the left of red on the Visible Spectrum) **Ask:** “What is infrared radiation?” (heat energy) **Ask:** “Can you see infrared rays?” (no)

6. Provide a **Focus for Media Interaction** by saying, “Now you will see a short segment about how rainbows are formed. I want you to tell me how it is like the prism we talked about earlier.” **Resume** and **Pause** when the narrator says “...little water prisms that refract the light and form a rainbow” (02:53) **Ask:** “How are rainbows formed?” (Rainbows are formed when sunlight is refracted in small droplets of water.) **Ask:** “How is this process like the prism we discussed earlier?” (Each droplet of water acts like a tiny prism, breaking the white light into the colors of the Visual Spectrum.)

7. Provide a **Focus for Media Interaction** by saying, “Now we are going to learn more about Isaac Newton’s theories about how we see colors. I want you to listen for the word *reflect*, and what actually reflects when we see a color.” **Resume** and **Pause** when the narrator says “White objects reflect all the colors, whereas black reflects no colors because black absorbs all the colors.” (03:56) **Ask:** “What happens when we look at a red apple?” (When white light hits the apple, the red color is reflected back at us while all the other colors are absorbed by the apple.) **Ask:** “What do we actually see when we look at different colored objects?” (...the colors we see are the colors reflected by objects.) **Ask:** “What is reflected when we see white objects?” (...all the colors are reflected, so we see white) **Ask:** “What is reflected when we see black objects?” (...no color is reflected because all the colors are absorbed by black objects)

8. Provide a **Focus for Media Interaction** by saying, “Now we will learn some more about colors of light and how they differ from the colors you use when you are painting in art class.

**Resume** and **Pause** when the narrator says “Color photographs are made up of these three pigments.” (05:22) **Ask**: “What are the primary colors of light?” (red, green and blue) **Ask**: “How do they differ from the primary colors of pigment, or paint?” (The primary colors of pigment are red, yellow and blue) **Say**: “We will experiment more with the primary colors of light and the primary colors of pigment after the video is over. The next section of video sums up what we have learned so far. I want you to be able to tell me the colors that are found in white light, and be able to explain how we see color. **Resume** and **Pause** when the narrator says, “Objects that are black absorb all the colors and reflect nothing.” (05:57)

**Ask**: “What is responsible for our ability to see color?” (light) **Ask**: “Do you think you can see color if there is no light on?” (no) “That explains why we see shapes at night, but no color, unless there is light on objects.” **Ask**: “What colors did we learn are found in white light?” (all the colors, red, orange, yellow, green, blue, indigo, and violet)

### **Culminating Activity**

1. Have students visit the following web sites to experience mixing the primary colors of light and the primary colors of pigment (paint). Have them analyze and compare what happens with each type of color mixing. Use the Primary Color Worksheet at the end of the lesson plan.

#### Mixing the Primary Colors of Light

<http://www.ontariosciencecentre.ca/scizone/games/adding/default.asp> This web site allows the user to see what happens to the primary colors of light, when they are mixed together.

#### Mixing the Primary Colors of Paint

<http://www.sanford-artedventures.com/play/color1/color1.html> This interactive series of sites introduces the element of color in art. It has a page where students choose which 2 primaries make up each of the secondary colors.

### **Assessment**

1. To test students’ knowledge of the concepts of translucent, transparent and opaque, have them visit the following website.

<http://t3.preservice.org/T0300715/testyourknowledge.html>

This website provides a visual and interactive test of students’ knowledge of these concepts.

2. Have students create a color wheel that demonstrates mixing the primary colors of pigments. Students should mix each primary color with another primary to create a secondary color.

3. Have students repeat the demonstration of mixing the primary colors of light by using three flashlights, each covered with a red, green or blue acetate, and a white background. This experiment was shown in the video portion of the lesson.

### **Cross-Curricular Extensions**

Language Arts:

1. Have students read trade books on their reading level about light and color.

2. Have students write descriptive paragraphs about what happens when you mix two primary colors together. This could also be done as a “how-to” paragraph.

3. Collect information about Isaac Newton and other scientific pioneers, organize information and write a paper about their contributions to the understanding of light and color.

Science:

1. During the study of light in fifth grade, students must understand the difference between transparent (Light travels through), translucent (some light travels through), and opaque (no light travels through). Brainstorm with the class about the meaning of these terms. Have students give examples of materials that will support each concept. Have students bring in items from home that will demonstrate each concept. The teacher should also bring in items to be sure each concept is represented. Have the students display their items to share with the class. Using the worksheet at the end of this lesson, students should prepare a list under the appropriate term that describes how much light it allows to go through it. See example of things the teacher might bring in:

<b>Transparent</b>	<b>Translucent</b>	<b>Opaque</b>
transparency	plastic shower curtain	solid color plastic lids
plastic wrap	tissue paper	construction paper
clear glass *	waxed paper	paper plates
laminating material	”glue chip” glass	aluminum foil
clear plastic lids	paper towel	felt
clear plastic plates	plastic lids	styrofoam trays
		cardboard
		tin foil
		wood
		cloth

2. Students can make a periscope or kaleidoscope to demonstrate what happens when you bend light.
3. During the study of light in 8<sup>th</sup> grade, students must be able to identify the parts of the Electromagnetic Spectrum, including the relationship between frequency and wave length of each. On poster board, have students find or create pictures that demonstrate each part of the Electromagnetic Spectrum. For example:
- Radio waves (cellular phones, radio, satellite dish, radar gun, MRI machine)
  - Microwaves - microwave oven
  - Infrared waves (infrared goggles, heat-seeking missiles, body heat sensors, remote control, CD-rom drive, )
  - Visible light - rainbow, drawing of the colors seen in the visible spectrum of light (ROY G BIV)
  - Ultraviolet waves - sun, sunscreen, person with sunburned skin, wrinkled skin, fluorescent powder showing fingerprints
  - X rays - sample of a bone x ray
  - Gamma rays - atomic bomb, cancer cells (Gamma rays are used to destroy cancer cells)

### Social Studies:

Have students research the contributions of Galileo Galilei, Robert Hooke, Anton van Leeuwenhoek, and Isaac Newton, and have them give a report on their contributions in creating and using optical tools.

### Art:

1. Give students each a copy of the “Seeing Colors” worksheet. Have students take turns trying to say the colors they see, rather than the words that are printed. They are actually trying to read the color, not the color word. It’s interesting to see how difficult it is to make the brain see the color instead of the word.

2. Have students make color spinners using the three primary colors. (See templates in the back of the lesson.)

3. After making a color wheel using the three primary colors of paint, have students create a painting using only the three primary colors. They should make all the other colors by mixing different combinations of the primary colors.

### Movement Education:

1. For elementary age students, read the book Color Dance by Ann Jonas. Hand out the translucent colored scarves, one to each student. Students should create a dance that will demonstrate color mixing by overlapping scarves with the different colors that each student has. Compare their findings to the art activity above.

### Technology:

1. Have students plan a PowerPoint presentation showing what they have learned about light and color.

2. Have students visit the following websites to further explore the science of light and color:

- Light Science

<http://www.smv.org/pubs/PSSolutionsLightSci.pdf>

This is an activity guide that focuses on light, from the Science Museum of Virginia.

- Color Blindness

<http://www.geocities.com/Heartland/8833/coloreye.html> This website allows students to

check the functionality of the color receptors in their own eyes by giving them examples of color combinations to decipher.

- Optical Illusions

<http://www.colorcube.com/illusions/illusion.htm> This website allows students to further explore the complexities of the human eye and how we see. They will look at a variety of

optical illusions that explain why we see the colors we see, and how color affects the way we see.

### Community Connections:

1. Have a graphic artist visit the class to demonstrate the four-color printing process (Using four colors in different combinations will create all other colors needed)

2. Visit a science museum to see a laser light show.

Name \_\_\_\_\_

<b>Transparent</b>	<b>Translucent</b>	<b>Opaque</b>

Name \_\_\_\_\_

<b>Transparent</b>	<b>Translucent</b>	<b>Opaque</b>

Name \_\_\_\_\_

## Primary Colors Worksheet

Mixing the Primary Colors of Light

<http://www.ontariosciencecentre.ca/scizone/games/adding/default.asp>

The Primary Colors of Light are RED, GREEN, AND BLUE. When you go to the website for the Primary colors of Light, try mixing 2 colors together by dragging one color on top of another. Answer the following questions while you try mixing the colors:

1. red + green = \_\_\_\_\_
2. green + blue = \_\_\_\_\_
3. blue + red = \_\_\_\_\_
4. red + green + blue = \_\_\_\_\_

Mixing the Primary Colors of Paint

<http://www.sanford-artedventures.com/play/color1/color1.html>

The Primary Colors of pigment (or paint) are red, yellow, and blue. When you go to the website for the primary colors of pigment (or paint), you must try to choose the two primary color that make a specific secondary color. Answer the following questions while you try mixing the colors:

5. red + yellow = \_\_\_\_\_
6. yellow + blue = \_\_\_\_\_
7. blue + red = \_\_\_\_\_
8. red + yellow + blue = \_\_\_\_\_

Conclusion: \_\_\_\_\_

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## SEEING COLORS

Look at the following colors. Do not read the word, say the color of the letters:

**Black Red Green**

**Purple White Blue**

**Orange Pink Red**

**Black Blue Purple**

**White Red Brown**

**Pink Yellow Blue**

Why is this so difficult to do? It is because the left side of your brain is trying to read the word, while the right side of your brain is seeing the color.

# Color Spinners

Copy this page onto heavyweight white paper such as card stock. Cut on the dotted lines. Give each student a row of 4 circles. Demonstrate drawing a line through the center of a circle. Have students do the same thing to one of their circles. Using two primary colors (red, blue, or yellow) color each half of the circle. Cut the circle out and punch a hole in the center. Push a short pencil through the center circle to create a color spinner. Spin the top to see the colors mix. Try different combinations of colors and try drawing more lines. You can also purchase inexpensive small plastic spinners from Oriental Trading Company. These circles will fit perfectly on the center spindle if you use a standard hole punch to take out the center..

