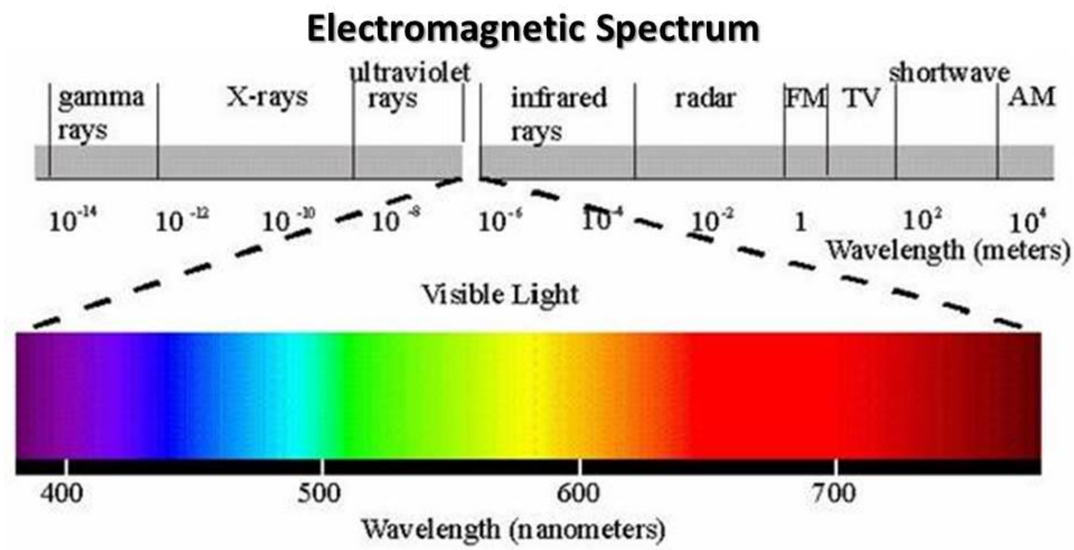
Teacher Notes

Color Me with Light (3-4)

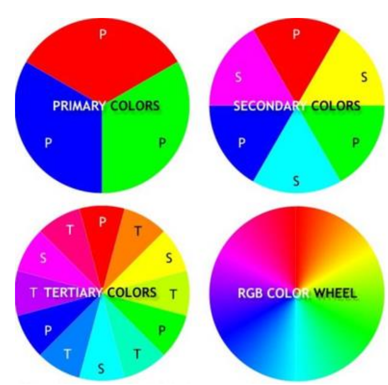
LOGISTICS
Class grade/age: 3-4th grade
Class size: 20 students
Instructional Time: 110 minutes
Location: Science Lab or Classroom
Safety Considerations: Use common sense safety. Do not shine any light directly into anyone's eyes.

BACKGROUND:
Light is energy that people can see. The ***electromagnetic spectrum*** is a continuum of energy wavelengths and frequencies from high energy *gamma rays* to low energy *radio waves*. Humans can see the energy from light in a very thin band of this spectrum called the ***visible light band***.



People see colors of *light* differently than colors of *pigment*. *Light* colors are an ***additive*** process while *pigment* colors are ***subtractive***. In the simplest sense, when primary colors of *light* are combined equally and white is formed, then it is an additive process. The human eye sees the combination of the actual colors ***emitted*** by the source(s) of light.

Conversely if the primary colors of *pigments* are combined equally and black is formed, then it is a subtractive process. In this case, the human eye sees only the colors which are ***reflected*** off the object; the colors not reflected are absorbed and subtracted from what is seen. The three primary colors of *light* are red, green, and blue (RGB). These three primary colors form the basis for all other colors of *light*. The secondary colors are yellow, cyan, and magenta; the tertiary colors are orange, yellow green, blue green, azure, violet, and rose.



The spectrum of these colors is commonly known as the RGB color wheel, referring to colors of light emitted from a light bulb, a television, a projector, or a computer screen. Review the chart below for the different color combinations and a computer's ratio numbers for programming color.

Visible Light Color	Type	Color Combination	RGB Computer Ratios
red	primary	NA	R=255
green	primary	NA	G=255
blue	primary	NA	B=255
yellow	secondary	red + green	R=255, G=255
cyan	secondary	green + blue	G=255, B=255
magenta	secondary	red + blue	R=255, B=255
orange	tertiary	red + yellow	R=255, G=128
yellow green	tertiary	green + yellow	R=128, G=255
blue green	tertiary	green + cyan	G=255, B=128
azure	tertiary	blue + cyan	G=128, B=255
rose	tertiary	red + magenta	R=255, B=128
violet	tertiary	blue + magenta	R=128, B=255
white		red + green + blue	R=255, G=255, B=255

When all the primary colors of *light* are mixed equally, the result is white light. Conversely, when all the primary colors of *pigment* are mixed equally, the result is black. This lesson will introduce the physics of *color and light* through an age-appropriate approach for students in grades 3-4.

SUMMARY OF ACTIVITIES

In Part 1, students will hypothesize about the resulting colors when the primary colors of light are mixed. They will test the validity of their hypotheses by observing what happens when those *light* colors are mixed. In Part 2, students will create a kaleidoscope using translucently colored acrylic beads. They will verify predicted colors present in their kaleidoscopes when tested using white light, followed by red, green, and blue light.

STANDARDS

NGSS-4-PS4.B. An object can be seen when light reflected from its surface enters the eyes.

NGSS-3-5-ETS1-1. Define a simple design problem that includes specific criteria for success and constraints on materials, time, and cost.

OBJECTIVES

The students will know …

1. that the primary colors of light mix to form secondary colors,
2. demonstrate an understanding of color and light through a final product.

Materials:
- Poster board – 1
- Projector & screen – 1
- Lamps – 3
- Light bulb, red – 1
- Light bulb, green – 1
- Light bulb, blue – 1
- Spectroscopes – 5 (1/group of four students)
- Pencils – 20 (1/student)
- Beads, acrylic, various translucent colors – 100 (5/student)
- Plastic cylinders, clear 12 cm w/3 cm diameter – 20 (1/student)
- Scissors – 10 (1/pair of students)
- Tape, clear – 5 rolls (1 roll/group of four students)
- Tape, masking – 5 rolls (1 roll/group of four students)
- Tape, black or silver duct – 2 rolls

Advanced Preparation Materials

Kaleidoscope Supply Prep
- Foil – 1 roll
- Paper, cardstock any color
- Tape, clear – 1 roll
- Scissors – 1
- Glue, stick – 1
- Pen, Sharpie, black – 1
- Compass – 1
- Ruler – 1
- Green cylinder covers, 3.0 cm diameter – 20
- Plastic cylinders, (soil collection tubes) 12 cm length w 3.0 cm diameter – 20
- Plastic film – 1 sheet
- Ziploc bag, sandwich size – 3
- Ziploc bag, gallon – 1

Advanced Preparation:
1) Prepare kaleidoscope supplies.
   - Mirror prisms – 20 (1/student)
     - Mirror card strips – 60 (3 strips/student)
       - Glue the foil onto one side of the cardstock paper sheets.
       - Measure and mark 2.5 cm x 9.0 cm strips on the white side of the combined cardstock & foil sheets using a ruler and a Sharpie.
       - Cut combined sheets into 2.5 cm x 9.0 cm strips. 60 strips are needed.
     - Construct prism
       - Configure 3 strips with the foil side facing inward into a prism shape.
       - Tape the outside edges to hold the prism together.
   - Clear, plastic circles – 20 (1/student)

  - Use the compass to draw 20 circles with a 3.5 cm diameter.
  - Cut the circles and place in a sandwich size Ziploc bag.
  - There should be 20.
- Green cylinder covers – 20 (1/student)
  - Drill a peep hole w/ at least a 1.0 cm diameter.
  - Place 20 green cylinder covers in a sandwich size Ziploc bag.
- Kaleidoscope cylinders – 20 (1/student)
  - Cut across the diameter of the cylinders to a length of 2.5 cm from the closed end.
  - There will be two pieces of the cylinder.
    - Place all 20 of the 2.5 cm cylinders with one closed end in a sandwich size Ziploc bag.
    - Place all 20 of the 9.5 cm open cylinder tubes in a gallon size Ziploc bag.

ACTIVITIES:

Activity 1: RGB (Red, Green, Blue) Light Mixing
Activity 2: Kreative Kaleidoscopes

RELEVANT FUN FACTS:

1) Bees can see the ultraviolet portion of the electromagnetic spectrum.
2) Snakes can see the infrared portion of the electromagnetic spectrum.
3) The speed of light is very fast at 3.0×10^8 m/sec!

Goal:
What are the primary colors of light? Are the primary colors of pigments?

Introduction — Estimated Time: 5 minutes

1) Enthusiastically welcome students to class and ask them what they know about color and light. (*Encourage and accept various responses*).
2) Reveal that today they will learn a little about the physics of color and light. Specifically they will explore how different colors of light mix together so we end up seeing certain colors.
3) Emphasize that today is about mixing *light* colors, which is different than *pigment* colors.
   - *Light* colors are created via an additive process while *pigment* colors are created via a subtractive process.
   - In the simplest sense, when the primary colors of light are combined equally, white is formed.
4) Discuss how the human eye sees only a small portion of light, known as visible light; there are other types of light out there in nature that we can't see, but other organisms can.
5) STORYLINE: *Please work as a group to develop your own story to go along with the activities herein.*

Goal:
How does light mix? What secondary colors form from the primary colors of light? How do the colors of light we see fit into the electromagnetic spectrum?

Activity 1: RGB (Red, Green, Blue) Light Mixing — Estimated Time: 15 minutes

Materials:

- Poster board, white large – 1
- Tape, masking – 1 roll
- Lamps – 3
- Light bulb, red – 1
- Light bulb, green – 1
- Light bulb, blue – 1

- Spectroscopes – 10 (1/group)

Procedures:

1) Mixing light: primary, secondary, and tertiary:
   - Make sure that the three lamps each with a different color light bulb are working and ready. Tape the poster board to the wall using masking tape. Make sure that all students can see the poster board no matter where they are seated in the classroom.
   - Turn off all lights and turn on one color of light alone at a time: red, green, and blue. Let students know up front that the primary colors of light are red, green, and blue, known as RGB. All other colors of light are based on how those three colors mix in different combinations.
   - Ask what color they think will form when two primary light colors are mixed; allow them to make a guess (hypothesize) and then show them. Allow them to state whether their guess (hypothesis) was correct or not.
2) Review how light is a type of electromagnetic radiation; that's just a big word/phase that means something is giving off energy in the form of light.
   - The part of the spectrum that humans can see is very tiny, the ***visible light band***. We are going to use a special tool called a ***spectroscope*** to observe the ***visible light band***.
3) Distribute the spectroscopes and allow them to make observations.
   - Tip: sometimes it helps to look at the edges of the inside of the cylinder instead of the opposite end of the cylinder to view the ***visible light band***.
4) Challenge them (as groups) to identify the order of the colors they see.

Transition to next activity: Ask students if their "light mixing" hypotheses were supported or refuted based on the results of the demo. Give them an opportunity to share some things they observed during the last activity. Allow each group to share the colors and the order they saw. Lead them to correct order of ROYGBIV (red, orange, yellow, green, blue, indigo, violet; some groups may have started with violet, which is fine). Have a rough sketch of the electromagnetic spectrum on the board (see the picture in the Background section of the lesson). Show them the scale of how very little of the entire electromagnetic spectrum that humans can see. Explain that snakes see infrared (seeing heat) and bees see ultraviolet (brightness of flowers). We see the thin, tiny band between those two; refer to the drawing you made on the board, and relate that to what they saw in the spectroscope.

Activity 2: Kreative Kaleidoscopes — Estimated Time: 30 minutes

Goal:
Can the principles of color and light be applied to create a kaleidoscope with desired colors?

Materials:

- Kaleidoscope cover – 20 (1/student – See Adv Prep)
- Beads, acrylic, various translucent colors – 140 (7/student)
- Plastic cylinders, long and clear 9.5 cm long w/3 cm diameter, open on both ends – 20 (1/student – See Adv Prep)
- Plastic cylinders, short and clear 2.5 cm long w/3 cm diameter, one end closed – 20 (1/student – See Adv Prep)
- Green cylinder covers – 20 (1/student – See Adv Prep)
- Scissors – 10 (1/pair of students)
- Tape, clear – 5 (1/group of four students)
- Tape, masking – 5 (1/group of four students)
- Tape, duct – 2 rolls
- Mirror prisms – 20 (1/student – See Adv Prep)
- Plastic disc, clear w 3.5 cm diameter – 20 (1/student – See Adv Prep)

Procedures:
1) Tell them that the final product of their training is a kaleidoscope that will show the color beads they desire in white, red, green, and blue light.
2) Have students gather their supplies. They can share the common supplies of scissors, and tape in pairs or groups of four for some supplies.
3) Place the prism in the longer clear open ended cylinder, flushed against one end.
4) Based on the colors a student desires, have them choose 5-7 beads. Drop the beads into the smaller cylinder with one closed end. The beads need to move around in the compartment. Place the 3.5 cm clear plastic disc on the end of the bead compartment and use clear tape to attach and seal the beads in.
5) Connect the two cylinders together taping around both where they join on the outside of the cylinder. The prism should be flushed against the bead compartment.
6) Push the green cylinder cover with the peep hole in at the other end of the long cylinder where the prism is located.
7) Cut two pieces of black duct tape for each student to finish the outside of their kaleidoscope when they are done putting the various pieces together.
8) Have them look through their kaleidoscopes in white, red, green, and blue light. They can also try one another's kaleidoscopes as well.

Goal:
Did students end up with the desired colors for their kaleidoscopes? What did students learn about color and light?

WRAP-UP ENTIRE LESSON **Estimated Time: 5 minutes**

Procedure:
1) Probe students about what they learned around color and light. (Refer to the chart in the Background section for the answers to some of the following questions.)
   - What are the primary colors of light? RGB
     - Red
     - Green
     - Blue
   - What are the secondary colors? What primary colors mix to form the different secondary colors of light?
     - Yellow (red + green)
     - Cyan (green + blue)
     - Magenta (red + blue)
   - What is the ***visible light band***? Is that a big part or a tiny part of the electromagnetic spectrum? The visible light band is the tiny part of the electromagnetic spectrum that humans can see.
2) Ask students to think about why their kaleidoscope is special. Allow time for a few students to share why their kaleidoscope is special.

Assessment:
1) Hypotheses outcomes (supported or refuted) regarding primary light colors mixing.
2) Exploration results of viewing the ***visible light band*** using a spectroscope.
3) Desired colors in various color lights of their kaleidoscope beads.
4) Survey Questions:
   - What kind of energy is measured by the electromagnetic spectrum? ***Light***
   - List the primary colors of light. ***Red, Green, Blue***
   - Name an organism that can see infrared light***. Snake***
   - Name an organism that can see ultraviolet light. ***Honey bee***

Clean-up:
1) Students can take home their kaleidoscope.

2) Students should clean up their work areas; dismiss when class is satisfactory.

EXTENSIONS/ADAPTATIONS

1. Use a spectroscope with ruler guides to obtain the actual wavelengths along the different colors of the electromagnetic spectrum's visible light band.
2. Hypothesize and test how changing the length of the kaleidoscope or the mirror prism inside will affect its operation, then build it to test the result.
3. Mix pigment colors and compare to mixing light.

REFERENCES:

1. Annenberg Learner Workshop. (n.d.). Shedding light: Laws of light. In *Annenberg Learner*. Retrieved December 21, 2015, from http://www.learner.org/workshops/sheddinglight/workshops/workshop2.html

2. Brown, C. (n.d.). Digital color theory class. In *The Art Institutes*. Retrieved December 28, 2015, from http://crbsite.com/new_aicasf/digital_color_current/dc_color_wheels.html

3. Exploratorium Teacher Institute. (n.d.). Colored shadows. In *Exploratorium*. Retrieved December 21, 2015, from http://www.exploratorium.edu/snacks/colored-shadows

4. Kate. (2010, October 8). Kitchen roll kaleidoscope. In *Mini-Eco*. Retrieved December 28, 2015, from http://www.minieco.co.uk/kitchen-roll-kaleidoscope/

5. Museum of Science and Industry, Chicago. (n.d.). Three colors of light. In *Museum of Science and Industry Chicago*. Retrieved December 21, 2015, from http://www.msichicago.org/education/educator-resources/classroom-activities/educator-info/activities/three-colors-of-light-1/

6. NASA. (2007, March 27). Visible light waves. In *National Aeronautics and Space Administration (NASA)*. Retrieved December 21, 2015, from http://missionscience.nasa.gov/ems/09_visiblelight.html

7. Oregon Museum of Science and Industry. (n.d.). Mixing primary colors. In *Explore Technology*. Retrieved December 21, 2015, from http://www.omsi.edu/tech/colormix.php

8. PBS. (n.d.). Primary colors of light and pigments. In *PBS Learning Media*. Retrieved December 21, 2015, from http://www.pbslearningmedia.org/resource/lsps07.sci.phys.energy.lightpigment/primary-colors-of-light-and-pigments/

9. Planinsic, G. (2004, March). Color light mixer for every student. *The Physics Teacher*, *42*, 138-142. Retrieved December 21, 2015, from http://www.fmf.uni-lj.si/~planinsic/articles/colormix.pdf

10. Science Buddies. (2015, July 11). Mixing light to make colors. *Science Buddies.* Retrieved December 21, 2015 from http://www.sciencebuddies.org/science-fair-projects/project_ideas/HumBeh_p021.shtml

11. Science Kids. (n.d.). Fun light facts for kids. In *Fun Science & Technology for Kids*. Retrieved December 28, 2015, from http://www.sciencekids.co.nz/sciencefacts/light.html

12. University of Waikato. (2012, April 4). Colours of light. In *Science Learning*. Retrieved December 21, 2015, from http://sciencelearn.org.nz/Contexts/Light-and-Sight/Science-Ideas-and-Concepts/Colours-of-light