

Lesson 3: Light (3 Days)

☐ Getting Started

Light is one kind of radiant energy. There are forms of light that we can see and forms of light that our eyes cannot see. The light we can see is called visible light. What do you know about light? Have you ever thought about where light comes from or how it is used? In this lesson you will explore the characteristics of light.

Stuff You Need

- a variety of objects
- alligator clips (kit)
- battery (kit)
- clay (kit)
- clear cups (kit)
- clear glass cup
- color wheel (kit)
- colored pencils
- dark cloth (kit)
- flashlights (kit)
- flashlights (kit)* (Activity 2 - optional)
- measuring spoons
- mirror (kit)
- motor (kit)
- note cards (kit)
- pencil
- piece of cardboard (kit)
- piece of white paper (kit)
- piece of wood (kit)
- red, blue, and green cellophane (kit)
- red, blue, and yellow food coloring (kit)
- rubber bands (kit)
- ruler
- scissors
- tape
- white paper

Ideas to Think About

- What is the relationship between light and color?
- What is the relationship between light and objects?

Things to Know

- When white light is split, it makes a rainbow.
- Light travels in waves.
- The primary colors of light are red, green, and blue.
- **Reflection of light** occurs when light bounces off a surface.
- **Absorption of light** occurs when light is taken in and not reflected off a surface.
- **Refraction** is the bending of light as it travels through a transparent surface.

Activities

☐ Activity 1: Light Sources

Brainstorm a list of light sources in your home and community and record them on a sheet of paper. Share your list with a parent.

☐ Activity 2: A Rainbow

Sunlight and electric light are white light. So how do rainbows appear in the sky? This experiment will help you split white light into a rainbow of colors using the scientific method. Review the steps of the scientific method below and then conduct the experiment on the page titled "A Rainbow."

NOTE: The mirror for this activity is with your Lesson 3, Activity 7 materials. The first part of this activity requires a sunny day, so if it's cloudy, wait for better weather. The second part of the activity can be done with a flashlight in a dark room, if needed.

- **Problem or Question:** What are you going to solve in the experiment? The problem or purpose explains what you hope to accomplish in the investigation.
- **Hypothesis:** How do you think it is going to turn out? Use the facts you already know to come up with a guess that makes sense.
- **Materials:** List of supplies you will need to complete the experiment.
- **Procedure:** What you must do to complete the experiment. Write down the steps you need to follow.
- **Data and Work:** Include the tables, observations, and work you did during the experiment. This section is where you keep very careful notes on everything you do and discover. Be sure you write down or draw what really happens, even if it's not what you thought would happen. At the end, look over all your data and think about it very hard. Think of the results of your procedure, or how everything turned out.
- **Conclusion:** You must say what you found out during the lab. Figure out whether your results agreed with your hypothesis or not. Put everything you observed together and try to make some sense out of it. The conclusion should answer the problem/questions.

☐ **Activity 3: Colors of Light**

In the previous experiment you learned that white light is actually made up of many different colors. The primary colors of light are red, green, and blue. These colors combine to form the other colors in a rainbow. Conduct the investigation described on the "Colors of Light" activity page.

Day 2☐ **Activity 4: Colors**

Have you ever wondered why our eyes see things in different colors? When light travels from an object and enters our eye, we can see the object. The light that is reflected from the object determines the color we see. A blue object appears blue because when white light shines on it, the object absorbs all other colors except blue. It reflects the color blue.

As you know, the primary colors of light are red, blue, and green; but the primary colors of pigments (solid or liquid forms of color, like paint) are red, blue, and yellow. Mixing colors with paint or food coloring produces a different outcome than when you mix different colors of light. Conduct the investigation described on the "Colors" activity page.

NOTE: Be sure to save the rest of the food coloring, which will be used in the next science unit.

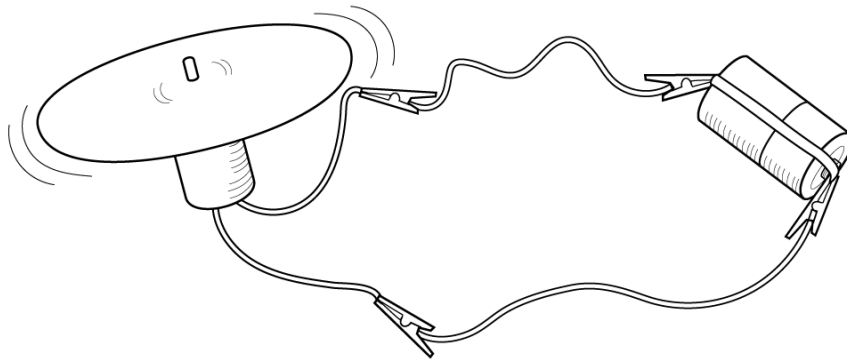
☐ **Activity 5: Color Wheels**

For this activity you will design a color wheel, attach it to a motor, and spin it. What color do you think you will see? Why?

Follow these steps:

1. Cut out one of the color wheels found in your science kit.
2. Use colored pencils to color the sections in this order: red, orange, yellow, green, blue, purple.
3. Next, set up the motor. Put a rubber band around the battery so that it is centered over the ends. Attach an alligator clip to the rubber band so that one side of the clip is touching the center of one end of the battery. Attach the other alligator clip to the other end of the battery.

4. Connect the other end of both clips to the wires of the motor. (See diagram.)
The motor should begin to run, and the shaft (the piece of metal sticking out from the motor) should begin to spin. Turn off the motor by unhooking the wires.
5. Put a piece of tape over the dot in the center of the wheel. Flip the wheel over and put a piece of tape on the back side too.
6. Poke a small hole through the dot on the wheel with something sharp, like a pencil, needle, or nail.
7. Now poke the shaft through the center of the wheel, with the colored side of the wheel facing up. The fit should be tight so that the wheel does not spin freely around the shaft. If the wheel is loose, tape the wheel to the shaft more securely. You may want to do this on the back side of the wheel.
8. Hook the motor back up and watch the color wheel spin.



What did you see?

What do you think would happen if you used different colors (e.g. yellow, purple, and orange)? Try different combinations of colors on the remaining color wheels. You can use as many or as few colors as you want on each wheel.

Discuss your results with your parent.

NOTE: Be sure to keep one color wheel as well as the motor, alligator clips, and battery. You will use them again in Lesson 4.

☐ Activity 6: Light Travels

What path do you think light takes as it travels from one place to another? Does it move back and forth? Spread out like a fan? Is it crooked? Follow the directions for this experiment on the "Light Travels" activity page.

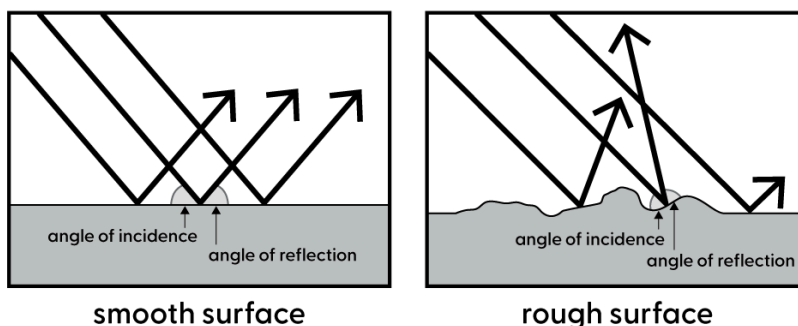
Day 3☐ **Activity 7: Reflection and Absorption**

Note: Be sure to keep the mirror from this activity to use in the Living Seas unit.

Things that make light are called light sources. Things that are not light sources give off light by absorbing some light colors and reflecting others. A blue object appears blue because it absorbs all colors except blue. A yellow object absorbs blue light but reflects red and green light (red and green light make yellow).

What color do you think you will see if an object absorbs all the colors of the rainbow (all the colors of light) and reflects none of them?

Reflection occurs when light bounces off of objects. The amount of light reflected off of an object depends on whether the surface is rough or smooth. On a rough surface the light scatters, but if a surface is smooth and flat, the light will bounce off it at equal angles. The angle at which light hits a surface is called the *angle of incidence*. The angle at which light is reflected is called the *angle of reflection*.

Angles of Incidence and Reflection

Watch the video to find out more about absorption and angles of incidence and reflection. (The video covers refraction as well, which you will experiment with in Activity 8.)



Light Absorption, Reflection, and Refraction

www.beyondthepage.com/link/11837/

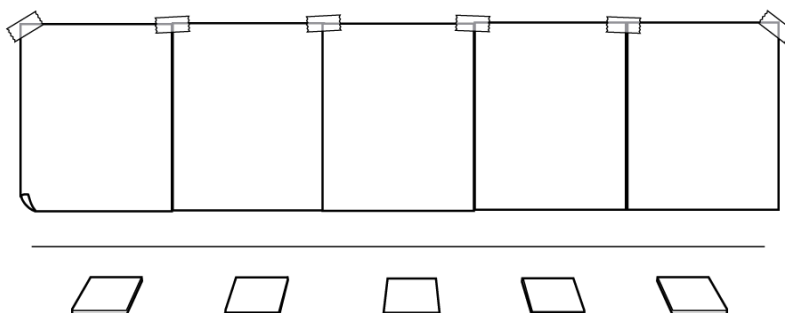
Gather the materials listed on the "Reflection and Absorption" activity page. Perform the following two tests.

Test 1:

1. Find a room that can be darkened (by closing curtains or turning off a light). Place the cardboard, fabric, wood, and paper in a row on the floor or on a flat surface.
2. Darken the room.
3. Shine a flashlight onto each material, one at a time. Make sure you and the flashlight are about the same distance from each of them.
4. Notice what color you see for each object, and record your results on the "Reflection and Absorption" activity page.
5. Decide whether the objects are reflecting light, absorbing light, or both. If something absorbs all the colors of the rainbow and reflects none, you will see black. If something reflects all of the colors and absorbs none, you will see white. If you see a color other than black, you know your item absorbs some colors and reflects others. Record your results on the activity page.

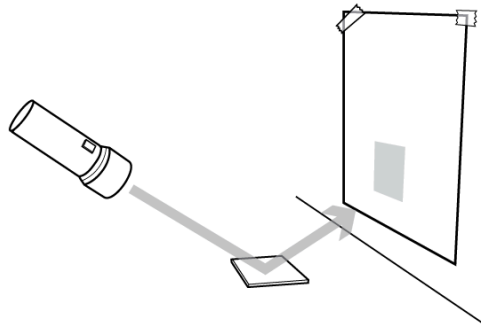
Test 2:

1. Find a room that can be darkened (by closing curtains or turning off a light). Line up the mirror, cardboard, fabric, wood, and paper in a row on the floor. Space the objects about 6 inches apart from each other, and 6-12 inches from an empty wall, as shown in the following illustration.



2. Tape white paper to the wall behind each object, a few inches above the floor.
3. Darken the room.
4. Shine the flashlight at an angle on the mirror.

5. On the "Reflection and Absorption" activity page, draw the angle of incidence you observe for light coming from the flashlight toward the mirror and the angle(s) of the light going away from the mirror toward the wall (the angle of reflection). The following illustration is an example of how you might draw the mirror's angles of light on the activity page. You can also refer to the diagram at the beginning of this activity.



6. As you draw, notice how bright or dim the light on the wall is, and how spread out the light is. Use arrows of different sizes and weight to communicate these details as well as to capture the angles of the beams of light. For example, the mirror will have a bright, focused beam, so you may show that by drawing a single arrow that is thick and dark.
7. Keep the angle of the flashlight the same and repeat for the other four objects. Unlike with the mirror, it will be hard to see exactly where the light is reflecting onto the wall. To get an idea of where the light is reflecting, you might want to change the angle of the flashlight and watch what happens to the light on the wall. Return to the original angle before drawing your pictures. In your drawings, remember to show these three things: how bright or dim the light on the wall is, how spread out the light on the wall is, and the angles of the beams of light.
8. Answer the question at the bottom of the activity page and discuss your findings with a parent.

☐ Activity 8: Refraction

Refraction is the bending of light. Light bends as it passes from one transparent medium to another at an angle. Light responds differently to transparent objects, such as glass or water, than it does when it hits objects that you cannot see through.

Put a pencil in a clear glass of water. What does the pencil look like? The light is traveling at an angle, so one part of the light hits the water before the other. The

water bends the light. You can also observe refraction by going in a dark room, putting the glass of water on a white sheet of paper, and shining a flashlight through the water. What happens? Does the light that hits the glass of water come out in the same way it went in?

A magnifying glass makes things look larger. Have you ever wondered why? The lens refracts light. The lens is wider in the middle than around the edge, and the bottom curves outward. This makes the object appear larger. If the bottom curved inward, the refracted light would make the object look smaller. Telescopes, microscopes, and cameras all refract light.

☐ **Activity 9: Shadows**

What happens when you go in a dark room, shine a flashlight on the wall, and put your hand between the light and the wall? Try it now.

A shadow is cast when you block out light. Practice making different types of shadows in a dark room with a flashlight and a variety of objects. It might be helpful to have an assistant hold the light source. How do you make the shadow change? On the "Shadows" activity page, write three observations about shadows.

Watch the following video about shadows. When you are finished, complete the rest of the "Shadows" activity page.



Shadows

www.beyondthepage.com/link/11838/

Wrapping Up

Over the past few days, you have learned about the special characteristics of light. Review the facts about light in the "Things to Know" section. Be sure you understand the difference between light colors and paint colors. Can you explain the relationship between light and other objects, whether they absorb, reflect, or refract light?

A Rainbow

Conduct this experiment on a sunny day.

Question: Can a rainbow be made from white sunlight?

Hypothesis: _____

Procedure:

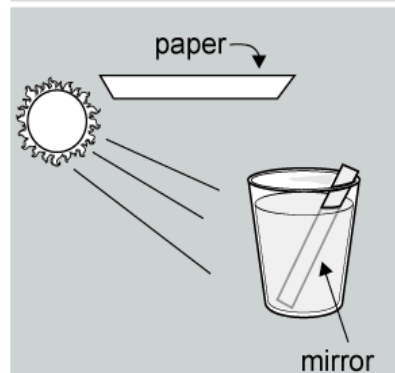
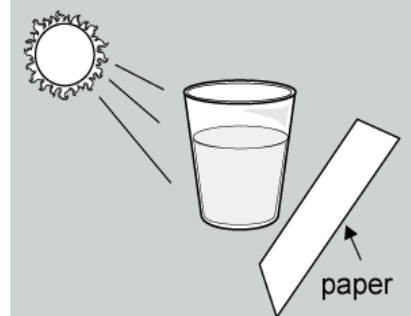
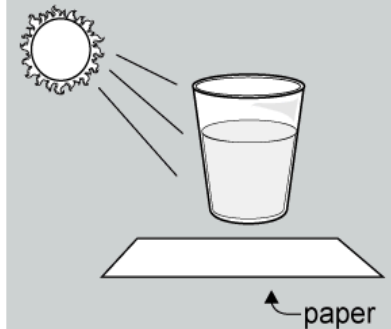
1. Fill the glass full of water.
2. Find a window that receives direct sunlight.
3. Place the paper on the floor or on a table and hold the cup of water just above it. Make sure sunlight is passing directly through the cup. If you see only shadows or white light, hold the paper in one hand and the cup in your other hand and move them both around at different angles.
4. Try this variation too! Place the cup on the floor, table, or windowsill in direct sunlight. Hold the paper in one hand and the mirror in your other hand. Put the mirror in the water at an angle so that sunlight reflects off of it. (NOTE: Don't look at the mirror! The sunlight can damage your eyes.) Move the paper around and adjust the angle of the mirror until the paper catches the reflected sunlight.

Results (what happened?): _____

Conclusion: A rainbow (can / cannot) be made from white light.

Materials:

- clear, smooth drinking glass
- a sheet of white paper
- mirror (kit)
- colored pencils

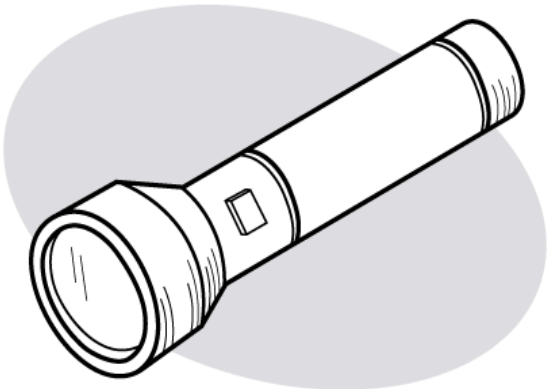


Illustrate the colors from the rainbow in your experiment. Be sure to arrange the colors in the order they appear.

COLORS of LIGHT

Materials:

- red, blue, and green cellophane (kit)
- 3 flashlights (kit)
- note card (kit)
- rubber bands (kit)



Procedure:

1. Use a rubber band to secure one piece of cellophane (one red, one blue, one green) to the end of each flashlight.
2. Go into a dark room and place another piece of cellophane in front of a flashlight as described on the chart below.
3. Place a note card 6-8 inches in front of the flashlight and then turn the flashlight on.
4. Record the color shown on the card.
5. Repeat Steps 2-4 for the remaining flashlights.

Flashlight	Cellophane in front of flashlight	Color on card
Red	Blue	
Blue	Green	
Green	Red	

Now shine the red, green, and blue flashlights at the same time onto the same spot on the note card. What do you see?

COLORS

**Materials:**

clear cups (kit)

measuring spoons

red, blue, and yellow food coloring (kit)

Question: What will you get when you mix equal amounts of different colors of water?

Hypothesis: _____

Procedure:

1. Fill three clear plastic cups $\frac{1}{2}$ to $\frac{2}{3}$ full of water.
2. Add 5 drops of red food coloring to the first cup, 10 drops of yellow food coloring to the second cup, and 8 drops of blue food coloring to the third cup.
3. Into a fourth plastic cup, mix 2 tablespoons of red water and 2 tablespoons of blue water. Record your result in the "Results" section.
4. Dump out the red/blue mixture from the fourth cup and rinse out the cup.
5. Repeat Steps 3 and 4 using red and yellow. Record your results.
6. Repeat Steps 3 and 4 using yellow and blue. Record your results.
7. For the last test, put 1 tablespoon of yellow into the cup. Add 1 tablespoon of red. Then add 1 tablespoon of blue. Write down what you observe.

Results:

What happens when you mix red and blue water? _____

What happens when you mix red and yellow water? _____

What happens when you mix yellow and blue water? _____

What happens as you mix all three colors together? _____

Questions:

Did the mixture get lighter or darker as you added all three colors to the cup?

How is mixing colors of water different from mixing colors of light?

LIGHT TRAVELS

Materials:

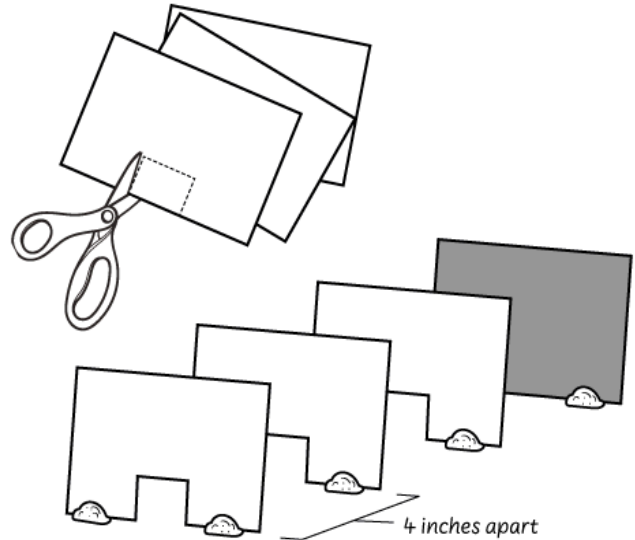
- 3 note cards (kit)
- piece of cardboard (kit)
- ruler
- clay (kit)
- flashlight (kit)
- scissors

Question: What does the path of light look like as it travels?

Hypothesis: _____

Procedure:

1. Cut a 1-inch notch out of three note cards in the exact same spot along the bottom edge of each card.
2. Press the note cards into small pieces of clay so that they stand upright. Press the piece of cardboard into a piece of clay, too.
3. Find a room that can be darkened. Set up the note cards in a row so that the notches are lined up. Space the cards about four inches apart.
4. Put the piece of cardboard at the end of the row, about four inches from the last card.
5. Darken the room. Shine your flashlight through the holes in the note cards. Observe what you see on the cardboard.
6. Move one card an inch to the right. What happens? Record your result in the Data section.
7. Move another card an inch to the left. What happens? Record your result in the Data section.
8. Try moving the cards in a variety of different positions and see if the light shines through.



Data:

What happens when one card is moved to the right?

What happens when one card is moved to the left?

What position do the cards have to be in so that the light will shine through on the cardboard?

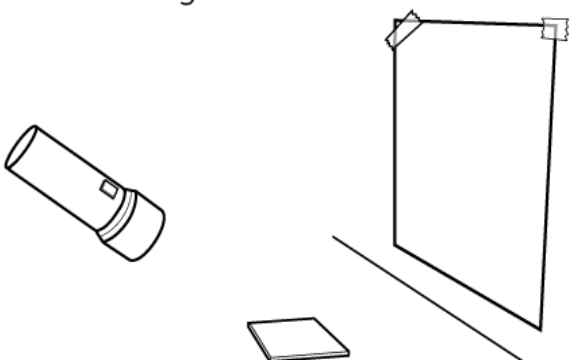
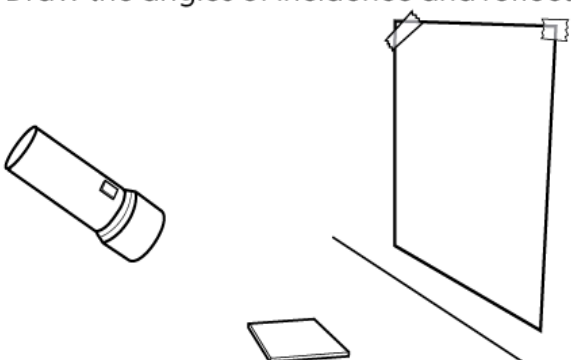
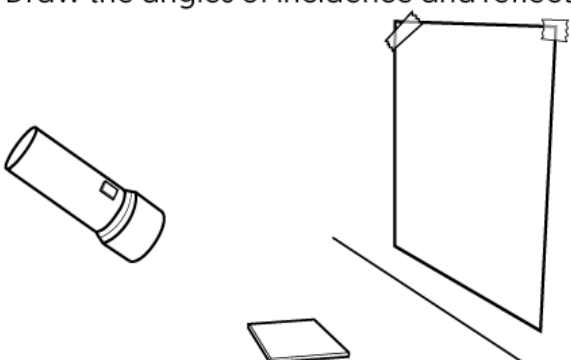
Conclusion:

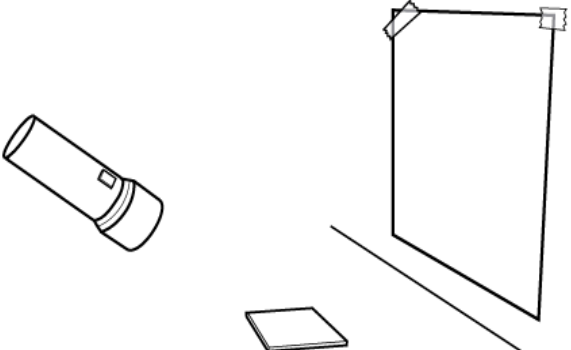
What does this tell you about the path of light? _____

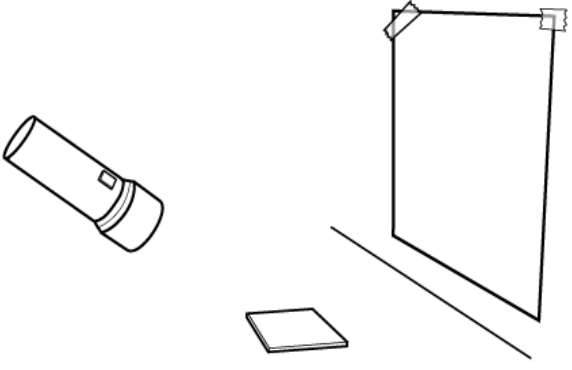
Reflection and Absorption

Materials:

- flashlight (kit)
- mirror (kit)
- white paper (5 sheets)
- piece of white paper (kit)
- dark cloth (kit)
- tape
- piece of cardboard (kit)
- piece of wood (kit)

Wood	Test 1: When you shine a light directly onto the wood, what color do you see? _____ This color means that light is being: <i>Reflected / Absorbed / Both</i> (Circle one)	Test 2: Draw the angles of incidence and reflection. 	#
White Paper	Test 1: When you shine a light directly onto the paper, what color do you see? _____ This color means that light is being: <i>Reflected / Absorbed / Both</i> (Circle one)	Test 2: Draw the angles of incidence and reflection. 	#
Cardboard	Test 1: When you shine a light directly onto the cardboard, what color do you see? _____ This color means that light is being: <i>Reflected / Absorbed / Both</i> (Circle one)	Test 2: Draw the angles of incidence and reflection. 	#

Fabric	Test 1: When you shine a light directly onto the fabric, what color do you see? _____ This color means that light is being: <i>Reflected / Absorbed / Both</i> (Circle one)	Test 2: Draw the angles of incidence and reflection.	#
			

Mirror	Test 2: Draw the angles of incidence and reflection.
	

Number the items from most reflective to least reflective according to the amount and pattern of light each item reflected onto the wall. How did the color and texture of each object affect the way it reflected or absorbed light?

Shadows

Materials:

- flashligh (kit)
- a variety of objects

Practice making different types of shadows with the objects you chose. How can you make the shadows change? Write three observations:

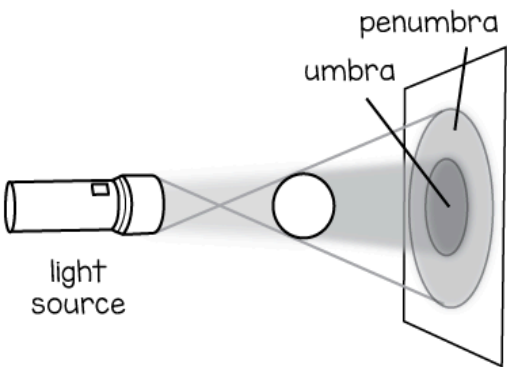
1. _____
2. _____
3. _____

Watch the video. Then try these tests. You can refer back to the video to help you as needed.

1. Find a transparent object (see-through), a translucent object (a little bit see-through), and an opaque object (not see-through) from around your house. See what happens when you try to make a shadow with each of these objects. Write what you observe:

Object	Type	What happened?
	transparent	
	translucent	
	opaque	

2. Choose an opaque object and try to create a shadow with a clear umbra and penumbra.
3. Discuss any problems you had with creating a clear umbra and penumbra. How did you solve them?



Lesson 3: Light (3 Days)

Getting Started

? Ideas to Think About

- What is the relationship between light and color?
- What is the relationship between light and objects?



Things to Know

- When white light is split, it makes a rainbow.
- Light travels in waves.
- The primary colors of light are red, green, and blue.
- **Reflection of light** occurs when light bounces off a surface.
- **Absorption of light** occurs when light is taken in and not reflected off a surface.
- **Refraction** is the bending of light as it travels through a transparent surface.

⦿ Skills

- Recognize that light has a source and travels in a direction. (S)
- Observe that light can be reflected off or absorbed by different surfaces. (S)
- Recognize the difference between colors of light and colors of pigment. (S)
- Understand that a rainbow is white light that has been split. (S)

Introducing the Lesson

Explain to your child that over the next three days he will explore energy in the form of light. Light has many unique characteristics, and without it we would not be able to see anything at all.

Activities

Activity 1: Light Sources

Review your child's list of light sources and add any additional ones you can think of.

Activity 2: A Rainbow

Your child will conduct an experiment to try to produce a rainbow.

NOTE: The first part of this activity requires a sunny day, so your child may need to come back to it later if today is cloudy. However, your child can try the mirror variation of the experiment on a cloudy day by using a flashlight in a dark room.

After your child conducts the experiment, review his findings. Explain that the sunlight should have passed through the glass of water and split into rainbow colors. Those colors should appear on the paper. If this did not occur for your child, encourage him to repeat the experiment and try the variation with the mirror.

Explain that white light is made up of many colors mixed together. Isaac Newton proved this over 300 years ago. In a dark room, he directed a beam of sunlight through a small slit and prism. The prism bent

(refracted) the white light and a spectrum (rainbow) of colors fanned out. In nature, a rainbow forms when raindrops separate white light.

Activity 3: Colors of Light

Tell your child the unusual names for the colors he made during the experiment. Explain that when you shine the light through red and blue cellophane, you make the color magenta, when you shine it through blue and green, you make the color cyan, and when you shine it through red and green you make the color yellow. When you mix all the colors of light, you get white light.

Day 2

Activity 4: Colors

NOTE: Be sure to save the rest of the food coloring, which will be used in the next science unit.

Here your child will investigate what happens when colors of paint are mixed compared to when colors of light are mixed. When he finishes, discuss how when the colors of water were mixed, the water got darker. But, when colors of light are mixed, they get lighter.

Show your child the following graphic. Tell him that light travels in waves and that each color is actually a different sized wave. Explain that we are able to see colors in clothing and other products because they absorb and reflect parts of white light. The things that determine what color we see are called pigments. So why does red paint look red? Well, the pigments in red paint absorb all wavelengths of light except for red. The red wavelength is reflected off of the paint onto our eyes so we see the paint as red. As you mix paint colors together, there will be more and more wavelengths of light absorbed by the mix of pigments in the paint. This also means there are fewer wavelengths of light (or colors) to get reflected to our eyes. Eventually, if every wavelength was absorbed after mixing pigments together, you would see black because there is no light left to be reflected off of the object to our eyes. This type of color mixing is called "subtractive color mixing" because colors of light are being subtracted as more wavelengths are absorbed by the different colored pigments.

What about light? Why did it get lighter when the colored flashlights mixed? Since we are talking about the SOURCE of the light, instead of the object reflecting the light (like paint), mixing colors of light looks different. This type of color mixing is called "additive color mixing." In this case, as you add more wavelengths of light together, it will get lighter and lighter. So it makes sense why, in Activity 3, mixing the three different colors made white light.

Refer to the following image at the following web link to see the difference between additive and subtractive color mixing.



Additive vs. Subtractive Color Mixing

www.beyondthepage.com/link/11896/

Activity 5: Color Wheels

Your child will set up a simple motor to spin a color wheel. Assist as needed. As the color wheel with all the colors of the rainbow spins, your child should see a white-ish blur. When he finishes investigating his color wheels, explain that when the color wheel spins, his eyes are averaging all of the colors, and white is made up of all the colors.

His eyes do the same thing when he watches TV or uses any sort of phone or computer screen. Screens work by projecting light, which our eyes translate into the colors and images we see on the screen. The pixels on a screen are made of the primary colors of light: red, blue, and green. By changing the percentage and intensity of pixels, a screen can show almost any color. You can show your child the following video, which shows an extremely magnified view of pixels. If your child looks closely, he will see the red, green, and blue sections of each pixel.

**Pixels on Screen Extreme Close-Up**

www.beyondthepage.com/link/11868/

Activity 6: Light Travels

Review the fact that light travels in a straight line from a light source. When it hits a surface it is blocked, because it is either being reflected or absorbed. Your child will explore reflection and absorption in the next activity.

Day 3**Activity 7: Reflection and Absorption**

Note: Be sure to keep the mirror from this activity to use in the Living Seas unit.

In this activity, your child will test light reflection and absorption. It must be performed in a room that can be darkened.

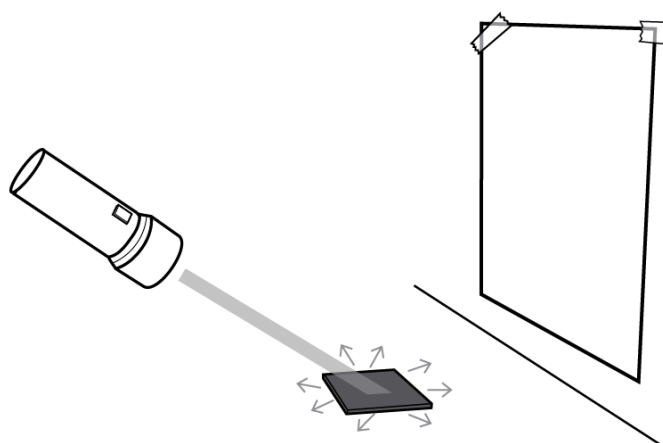
If space is an issue, Test 2 can be performed with only one sheet of paper taped to the wall. Your child will need to switch out the sample each time. It is easier to compare the samples with separate pieces of paper taped to the wall, but either method will work.

Discuss which surfaces reflected more light and which absorbed more light. Discuss whether some objects absorbed some light and reflected other colors of light. Analyze the angles your child observed, and discuss whether some of the light on the wall may have been reflected from the surface the objects were sitting on.

For Test 1, your child should note that the white paper reflected all light and the dark/black fabric absorbed all light. Because they look brown (and not white or black), the cardboard and wood both absorbed and reflected light.

For Test 2, results and drawings will vary. See the following example of a diagram for the piece of dark fabric (as well as the sample diagram for the mirror in the activity instructions). Your child should have noticed that the angle that the light travelled from the object to the wall changed depending on the angle from the flashlight to the object. The smoother the surface of the object, the more the light was all reflected at the same angle. The light hitting the wall from the mirror was much more highly focused than the light reflecting from the paper, cardboard, fabric, and wood.

The wood and dark fabric may seem to reflect very little light toward the wall because their irregular surfaces scatter the light in many directions rather than staying focused in a beam. Your child may also notice that the darker colored objects reflected less light because they absorbed more light. In general, your child should notice that the amount of light reflected onto the wall, from most to least, will be similar to this: mirror, white paper, wood and cardboard, fabric.



Activity 8: Refraction

Discuss the difference between reflection and refraction. Refraction occurs when light passes through a transparent surface and the light is bent. Transparent surfaces do not reflect or absorb light, they bend light.

Activity 9: Shadows

For this activity your child will experiment with making shadows. Discuss your child's observations about how to change a shadow. Observations may include that you can change a shadow by moving the light source from side to side, moving the light source closer or further away from the object, or moving the object closer or further away from the surface that the shadow appears on.

Check that your child correctly identified translucent, transparent, and opaque objects. Help him as needed if he has trouble creating an umbra and penumbra.

Wrapping Up

Questions to Discuss

- How are rainbows made? (When white light is split up, a rainbow of colors is formed. Rainbows in the sky are made when white light is split into colors by water drops.)

- How are paint (pigment) colors and light colors different? (The primary colors of each are different. Light's primary colors are red, blue, and green. The primary colors of paint or pigment are red, yellow, and blue. When all the colors of light are combined, they make white. When the colors of pigment are combined, they make black.)
- What is the difference between reflection and absorption? (Reflection is light bouncing off an object, and absorption is light being absorbed by an object.)
- What is refraction? (The bending of light as it travels through a transparent surface.)

Things to Review

Go over the steps of the scientific method with your child. Review the difference between reflection and absorption of light. Review the colors made when light is mixed: cyan, magenta, and yellow. Discuss that light travels in a straight line, and when a light is blocked, shadows form.