Objectives
After this lesson, students will be able to

O.4.1.1 State what happens to the light that strikes an object.
O.4.1.2 Describe what determines the color of an opaque, transparent, or translucent object.
O.4.1.3 Explain how mixing pigments is different from mixing colors of light.

Target Reading Skill
Building Vocabulary Explain that knowing the definition of key-concept words helps students understand what they read.

Answers
As students read each passage that contains a Key Term, remind them to write a sentence in their own words about the term. Encourage students to write one or two descriptive phrases to help them remember the Key Term. Invite students to share their sentences and phrases.

Preteach
Build Background Knowledge
Introducing Color
Ask: What color would you get if you combined blue and yellow paint? (Most students will say green.) Then ask: What color would you get if you combined blue and yellow light? (Students may say green.) Reply that the correct answer is white. Tell students that, in this section, they will learn why blue and yellow light combine to make white light.

Reading Preview
Key Concepts
- What happens to the light that strikes an object?
- What determines the color of an opaque, transparent, or translucent object?
- How is mixing pigments different from mixing colors of light?

Key Terms
- transparent material
- translucent material
- opaque material
- primary colors
- secondary color
- complementary colors
- pigment

Target Reading Skill
Building Vocabulary Using a word in a sentence helps you think about how to best explain the word. As you read, carefully note the definition of each Key Term. Also note other details in the paragraph that contains the definition. Use all this information to write a sentence using the Key Term.

How Do Colors Mix?
1. Cut a disk with a diameter of 10 cm out of white cardboard. Divide the disk into three equal-sized segments. Color one segment red, the next green, and the third blue.
2. Carefully punch two holes, 2 cm apart, on opposite sides of the center of the disk.
3. Thread a 1-m long string through the holes. Tie the ends of the string together to make a loop that passes through both holes.
4. With equal lengths of string on each side of the disk, tape the string in place. Turn the disk to wind up the string. Predict what color(s) you will see if the disk spins fast.
5. Spin the disk by pulling the loops to unwind the string.

Think It Over
Observing What color do you see as the wheel spins fast? Was your prediction correct?

It was hard work, but you are finally finished. You stand back to admire your work. Color is everywhere! The bright green grass rolls right up to the flower garden you just weeded. In the bright sunlight, you see patches of yellow daffodils, purple hyacinths, and red tulips. The sun’s light allows you to see each color. But sunlight is white light. What makes each flower appear to be a different color?
When Light Strikes an Object

To understand why objects have different colors, you need to know how light can interact with an object. When light strikes an object, the light can be reflected, transmitted, or absorbed. Think about a pair of sunglasses. If you hold the sunglasses in your hand, you can see light that reflects off the lenses. If you put the sunglasses on, you see light that is transmitted by the lenses. The lenses also absorb some light. That is why objects appear darker when seen through the lenses.

Lenses, like all objects, are made of one or more materials. Most materials can be classified as transparent, translucent, or opaque based on what happens to light that strikes the material.

**Transparent Materials** A transparent material transmits most of the light that strikes it. The light passes right through without being scattered. This allows you to see clearly what is on the other side. Clear glass, water, and air all are transparent materials. In Figure 1, you can clearly see the straw through the glass on the left.

**Translucent Materials** A translucent material (trans = through) scatters light as it passes through. You can usually see something behind a translucent object, but the details are blurred. Wax paper and a frosted glass like the middle glass in Figure 1 are translucent materials.

**Opaque Materials** An opaque material (opaque = not to see) reflects or absorbs all of the light that strikes it. You cannot see through opaque materials because light cannot pass through them. Wood, metal, and tightly woven fabric all are opaque materials. You cannot see the straw through the white glass in Figure 1 because the glass is opaque.

![Figure 1](https://example.com/image1.jpg)

**Figure 1**
Different types of materials reflect, transmit, and absorb different amounts of light. Comparing and Contrasting

How does a straw seen through transparent glass compare with a straw seen through translucent glass?

**Differentiated Instruction**

**English Learners/Beginning Comprehension: Key Concepts** Work with students to make a Venn diagram comparing and contrasting materials that are transparent and translucent. (Sample answer: Both types of materials let light pass through, but only transparent materials let you clearly see objects through them.)

**Learning modality:** visual

**English Learners/Intermediate Vocabulary: Word Analysis** Help students remember the difference between the similar-looking words, transparent and translucent. Write both words on the board and divide each word into its prefix and root. Explain that trans- means “through,” -parent means “to show,” and -lucent means “to shine.” Challenge students to define each word by combining the meanings of the prefix and root. **Learning modality:** verbal

**Instruct**

**When Light Strikes an Object**

**Teach Key Concepts**

**Transparent, Translucent, and Opaque Materials**

**Focus** Tell students that most materials are transparent, translucent, or opaque.

**Teach** Write the three terms on the board. Explain that materials of the three types differ in how much light they reflect, scatter, and transmit. State that transparent materials transmit most of the light without scattering it; translucent materials transmit most of the light but scatter it; opaque materials either reflect or absorb all the light, so no light is transmitted. Ask: What are some materials of each type in the classroom? (Sample answer: Wood for opaque material, glass for transparent material, thin paper for translucent material)

**Apply** Ask: Which type of material is water? (Transparent) **Learning modality:** verbal

**Independent Practice**

- Guided Reading and Study Worksheet: Light and Color
- **Student Edition on Audio CD**

**Monitor Progress**

**Skills Check** Have students make a table comparing and contrasting materials that are transparent, translucent, and opaque.

**Answers**

**Figure 1** A straw can be seen clearly through transparent glass. Through translucent glass, it can be seen only as a shape without details. It is reflected or absorbed.
The Color of Objects

Teach Key Concepts

Explaining an Object's Color

Focus Ask students to find objects of different colors in the classroom.

Teach Tell students that the color of an object depends on the material it is made of. State that objects made of opaque materials are the same color as the light they reflect, whereas objects made of transparent or translucent materials are the same color as the light they transmit. Ask: If a red object transmits red light, what type of material is it made of? (Transparent or translucent)

Apply Ask: Why is a blueberry blue? (It reflects blue light.) Why is blue glass blue? (The blue glass transmits only blue light.)

learning modality: logical/mathematical

Teaching Resources

Transparency 1339

Go Online

For: Links on colors
Visit: www.SciLinks.org
Web Code: scn-1543

Download a worksheet that will guide students' review of internet resources on colors.

Ask Ask: How can you explain your observations? (Sample answer: 'The red triangle reflects red light, but absorbs blue light and green light.)

learning modality: logical/mathematical

Light Reflected by Opaque Materials

Materials white light source, blue filter, green filter, red paper triangle, sheet of white paper

Time 10 minutes

Focus Say that the color of light shining on an opaque object affects the object's color.

Teach Place the red triangle on the sheet of white paper. Without letting students see the triangle in white light, have them view it in blue light and then in green light. (The triangle appears black in both cases.) Ask: What color will the triangle appear in white light? (Students should predict a color other than blue or green.) Show students the triangle in white light.

Apply Ask: How can you explain your observations? (Sample answer: 'The red triangle reflects red light, but absorbs blue light and green light.)

learning modality: logical/mathematical

The Color of Objects

If you know how light interacts with objects, you can explain why objects such as flowers have different colors. The color of any object depends on the material the object is made of and the color of light striking the object.

Color of Opaque Objects The color of an opaque object depends on the wavelengths of light that the object reflects. Every opaque object absorbs some wavelengths of light and reflects others. The color of an opaque object is the color of the light it reflects. For example, look at the apple shown at the top of Figure 2. The apple appears red because it reflects red wavelengths of light. The apple absorbs the other colors of light. The leaf looks green because it reflects green light and absorbs the other colors.

Objects can appear to change color if you view them in a different color of light. In red light, the apple appears red because there is red light for it to reflect. But the leaf appears black because there is no green light to reflect. In green light, the leaf looks green but the apple looks black. And in blue light, both the apple and the leaf look black.
Color of Transparent and Translucent Objects

Materials that are transparent or translucent allow only certain colors of light to pass through them. They reflect or absorb the other colors. The color of a transparent or translucent object is the color of the light it transmits. For example, when white light shines through a transparent blue glass, the glass appears blue because it transmits blue light.

Transparent or translucent materials are used to make color filters. For example, a piece of glass or plastic that allows only red light to pass through is a red color filter. When you look at an object through a color filter, the color of the object may appear different than when you see the object in white light, as shown in Figure 3.

The lenses in sunglasses often are color filters. For example, lenses that are tinted yellow are yellow filters. Lenses that are tinted green are green filters. When you put on these tinted sunglasses, some objects appear to change color. The color you see depends on the color of the filter and on the color of the object that appears in white light.

Figure 3
Color Filters
When you look at an apple through different filters, the color of the apple depends on the color of the filter.

Interpreting Photographs Why do both the apple and the leaves appear black through the blue filter?

The red filter transmits red light, so the apple looks red. But the leaf looks black.

The green filter transmits green light, so the leaf looks green. But the apple looks black.

The blue filter transmits blue light. Both the apple and the leaf look black.

Only red light passes through a red filter.

Skills Activity
Skills Focus: Developing hypotheses
Materials: American flag, light source, red and yellow filters
Time: 10 minutes
Tip: If the room is darkened, the effects of the filters will be more obvious.

Developing Hypotheses
1. Predict what colors you will see if you view a red, white, and blue flag through a red filter. Write a hypothesis of what the outcome will be. Write your hypothesis as an “If … then …” statement.
2. View an American flag using a red filter. What do you see? Is your hypothesis confirmed?
3. Repeat Steps 1 and 2 using a yellow filter.

Expected Outcome: With a red filter, both red and white stripes appear red, and the white stars appear to be red on a black background. With a yellow filter, the white stripes and stars appear yellow, the red stripes appear orange, and the blue areas appear black.

Help Students Read
DRTA Refer to the DRT guidelines in this chapter’s Content Refresher.

Before students read this page, ask: What determines the color of a transparent or translucent object? (Students may say the color of light the object reflects.) Tell students to scan the text under the heading Color of Transparent and Translucent Objects for the answer. Ask: Which sentence contains the answer? (The boldface sentence) Check students’ comprehension by asking: What color of light is transmitted by blue glass? (Blue light) What colors of light are absorbed by blue glass? (All except blue)

Teaching Resources
• Transparency O34

Color of Transmitted Light

Materials: differently-colored transparent or translucent materials such as glass, plastic, paper, and fabric; flashlight
Time: 15 minutes

Focus: Remind students that colored transparent and translucent materials transmit light of only certain colors.

Teach: In a darkened room, shine a flashlight on a white screen or wall. Then, shine the flashlight on the white surface through each of the colored materials. In each case, ask: How does the light appear? (It is the same color as the material it shines through.)

Apply: Ask: What conclusion can you draw about the color of light transmitted by transparent and translucent materials? (Sample answer: It is the same as the color of the material.) Learning modality: visual

Monitor Progress
Writing: Have students write a paragraph explaining why green apples and green traffic lights appear green.

Answers
Figure 2 A red apple reflects red light.
Figure 3 Only blue light is transmitted.

A color filter is a piece of glass or plastic that allows light of only a certain color to pass through.
Combining Colors

Teach Key Concepts

Primary and Secondary Colors

Focus Remind students that colors can combine to form different colors.

Teach On the board, write the headings Primary Colors of Light and Secondary Colors of Light. Under Primary Colors of Light, list red, green, and blue. State that white light consists of equal amounts of light of the three primary colors and that the primary colors combine in different ways to make all other colors of light. Under Secondary Colors of Light, list magenta, cyan, and yellow. State that secondary colors result from combining equal amounts of two primary colors. Call out that red and green are secondary colors (Red and blue) and that red and blue are complementary colors. Yellow and blue are complementary colors, as are cyan and red, and magenta and green.

Apply Ask: Which two primary colors of light combine to produce magenta light? (Red and blue)

Repeat this procedure for pigment colors, listing the primary and secondary pigment colors under the correct headings. Then, have students look at Figure 4. Ask: Which two primary colors of pigments combine to produce green pigment? (Cyan and yellow)

Address Misconceptions

Primary Colors of Light vs. Pigments

Students may not understand why they cannot combine red and green ink, paint, or dye to produce yellow, as shown in Figure 4. Help students overcome this misconception by having them color a square with a red marker and then with a green marker. When they are finished, ask: What happens when you combine red and green markers? (The square appears black.) Explain that Figure 4 applies only to light and that the colors in markers are pigments. Have students look at Figure 6, which applies to pigments. Point out that red and green are secondary colors in pigments and that they combine to produce black. learning modality: visual

Combining Colors

Color is used in painting, photography, theater lighting, and printing. People who work with color must learn how to produce a wide range of colors using just a few basic colors. Three colors that can combine to make any other color are called primary colors. Two primary colors combine in equal amounts to produce a secondary color.

Mixing Colors of Light

The primary colors of light are red, green, and blue. When combined in equal amounts, the three primary colors of light produce white light. If they are combined in different amounts, the primary colors can produce other colors. For example, red and green combine to form yellow light. Yellow is a secondary color of light because two primary colors produce it. The secondary colors of light are yellow (red + green), cyan (green + blue), and magenta (red + blue). Figure 4 shows the primary and secondary colors of light. A primary and a secondary color can combine to make white light. Any two colors that combine to form white light are called complementary colors. Yellow and blue are complementary colors, as are cyan and red, and magenta and green.

A color television produces many colors using only the primary colors of light—red, green, and blue. Figure 5 shows a magnified view of a color television screen. The picture in the screen is made up of little groups of red, green, and blue light. By varying the brightness of each colored bar, the television can produce thousands of different colors.

Differentiated Instruction

Less Proficient Readers

Listing Important Points About Light and Color Have students listen to this section of the chapter on the Student Edition on Audio CD. Tell them to write down important points as they listen. After students have finished, have them compare their list of points with the text and correct any errors or omissions. learning modality: verbal

Special Needs

Combining Colors of Pigment Have students make a colored diagram similar to Figure 6 by combining primary pigment colors using markers. Tell students to draw three overlapping circles (like the circles in the figure) and to color each circle with one of the primary pigment colors. Have students identify and label the secondary pigment colors that appear in the areas where the circles overlap. learning modality: kinesthetic
Mixing Pigments

How does a printer produce the many shades of colors you see in this textbook? Inks, paints, and dyes contain pigments, or colored substances that are used to color other materials. Pigments absorb some colors and reflect others. The color you see is the result of the colors that particular pigment reflects.

Mixing colors of pigments is different from mixing colors of light. As pigments are added together, fewer colors of light are reflected and more are absorbed. The more pigments that are combined, the darker the mixture looks. Cyan, yellow, and magenta are the primary colors of pigments. These colors combine in equal amounts to produce black. By combining pigments in varying amounts, you can produce many other colors. If you combine two primary colors of pigments, you get a secondary color, as shown in Figure 6. The secondary colors of pigments are red, green, and blue.

Look at the pictures in this book with a magnifying glass. You can see tiny dots of different colors of ink. The colors used are cyan, yellow, and magenta. Black ink is also used, so the printing process is called four-color printing.

What are pigments?

**Primary Colors of Pigments**

FIGURE 6

The primary colors of pigments combine in equal amounts to form black.
**Changing Colors**

**Prepare for Inquiry**

**Skills Objective**
After this lab, students will be able to
- observe how color filters affect white light
- infer what color(s) of light different filters allow through
- predict how colored objects appear through different filters

**Prep Time** 15 minutes
**Class Time** 40 minutes

**Advance Planning**
Gather colored objects, cellophane, flashlights, and shoe boxes.

**Safety**
Caution students to take care when using the scissors.

**Teaching Resources**
- Lab Worksheet: Changing Colors

**Guide Inquiry**

**Introduce the Procedure**
Tell students that they will observe objects in light of just one color at a time.

**Troubleshooting the Experiment**
Pair any students who are colorblind with those who are not.

**Expected Outcome**
Colored objects are their usual colors when viewed through a filter of the same color; they are another color when viewed through filters of other colors. White objects viewed through colored filters are the color of the filter.

**Analyze and Conclude**
1. Observing What did you see when you looked through the red cellophane? Explain why each object appeared as it did.
2. Observing What did you see when you looked through the blue cellophane? Explain.
3. Inferring What color(s) of light does each piece of cellophane allow through?
4. Predicting Predict what you would see under each piece of cellophane if you put a white object in the box. Test your prediction.
5. Predicting What do you think would happen if you viewed a red object through yellow cellophane? Draw a diagram to support your prediction. Then test you prediction.
6. Communicating Summarize your conclusions by drawing diagrams to show how each color filter affects white light. Write captions to explain your diagrams.

**Design an Experiment**
Do color filters work like pigments or like colors of light? Design an experiment to find out what happens if you shine a light through both a red and a green filter. Obtain your teacher’s permission before carrying out your investigation.

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### Changing Colors

**Problem**
How do color filters affect the appearance of objects in white light?

**Skills Focus**
observering, inferring, predicting

**Materials**
- shoe box
- scissors
- flashlight
- removable tape
- red object (such as a ripe tomato)
- yellow object (such as a ripe lemon)
- blue object (such as blue construction paper)
- red, green, and blue cellophane, enough to cover the top of the shoe box

**Procedure**
1. Carefully cut a large rectangular hole in the lid of the shoe box.
2. Carefully cut a small, round hole in the center of one of the ends of the shoe box.
3. Tape the red cellophane under the lid of the shoe box, covering the hole in the lid.
4. Place the objects in the box and put the lid on.
5. In a darkened room, shine the flashlight into the shoe box through the side hole. Note the apparent color of each object in the box.
6. Repeat Steps 3–5 using the other colors of cellophane.

4. Students may predict that a white object will appear the same color as the cellophane.
5. Students may predict that the red object will appear black. Their diagrams might show that light reflected by the red object is absorbed by the yellow cellophane. By viewing a red object through yellow cellophane, they will see that the red object appears orange.
6. Students’ diagrams are expected to show that each colored filter transmits light of its own color.

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### Analyze and Conclude

1. Observing What did you see when you looked through the red cellophane? Explain why each object appeared as it did.
2. Observing What did you see when you looked through the blue cellophane? Explain.
3. Inferring What color(s) of light does each piece of cellophane allow through?
4. Predicting Predict what you would see under each piece of cellophane if you put a white object in the box. Test your prediction.
5. Predicting What do you think would happen if you viewed a red object through yellow cellophane? Draw a diagram to support your prediction. Then test you prediction.
6. Communicating Summarize your conclusions by drawing diagrams to show how each color filter affects white light. Write captions to explain your diagrams.

### Design an Experiment
Do color filters work like pigments or like colors of light? Design an experiment to find out what happens if you shine a light through both a red and a green filter. Obtain your teacher’s permission before carrying out your investigation.

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### Extend Inquiry

**Design an Experiment**
Experiments should test whether overlapping red and green filters produce yellow or black. The filters are, in fact, more like pigments, because overlapping red and green filters produce gray or black.