Topic 4.2

How does light interact with objects to give them colour?

Key Concepts

- Light can be reflected, absorbed, or transmitted by objects.
- Objects can absorb some colours and reflect or transmit others.

Key Skills

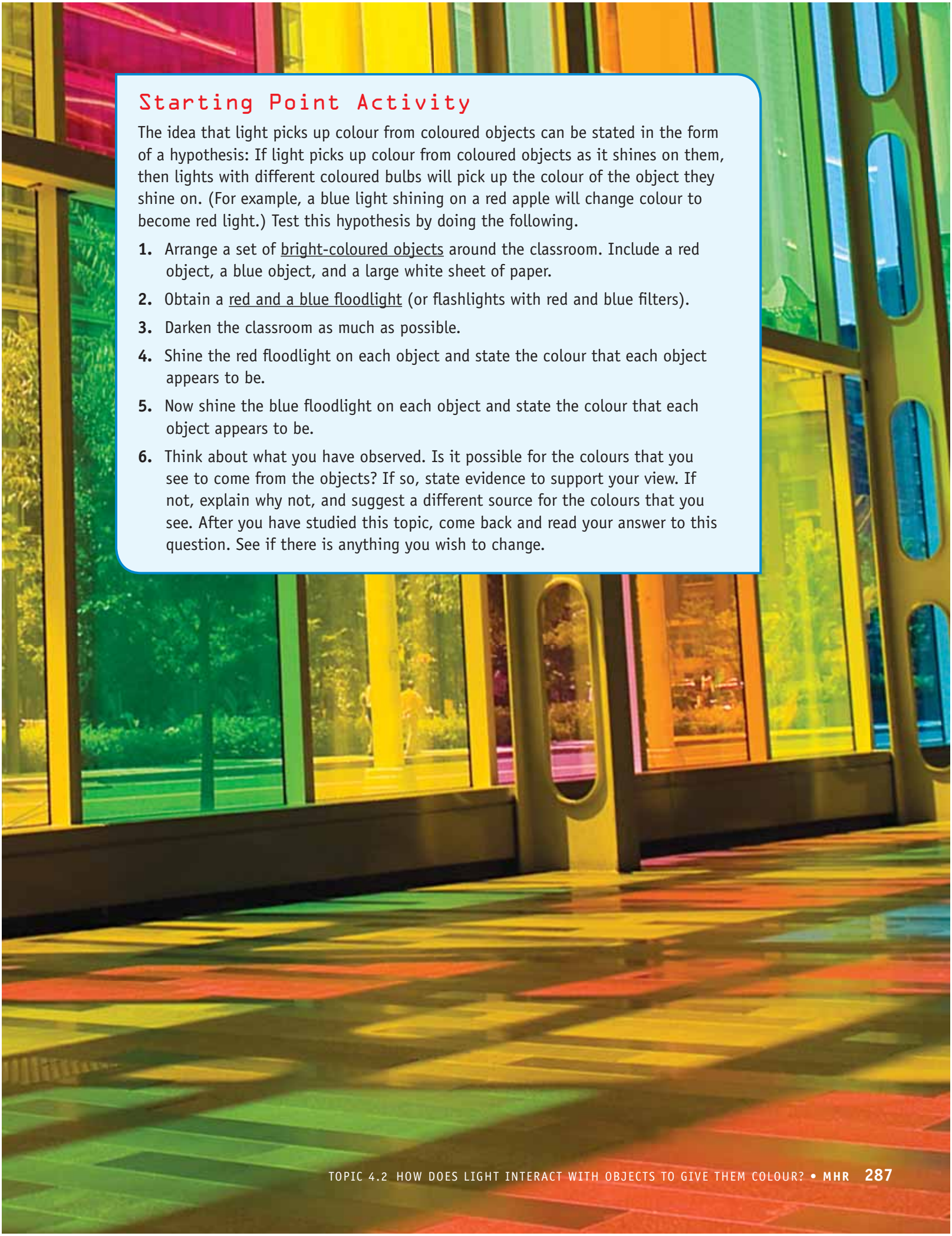
Inquiry

Key Terms

ray
reflection
absorption
transmission
transparent
translucent
opaque

On a bright day, sunlight streams through a stained glass window and fills the room with gentle beauty. Thanks to the stained glass, colour is everywhere. But what is the source of the colour? Up until the 1600s, most people would have said that the colour came from the glass. For this answer to be correct, the window somehow would have painted colour onto the white light from the Sun. In a similar way, they would have said that a red brick gave its "redness" to the light that fell upon it.

The idea that light picks up colour from objects may seem reasonable. But is there evidence to support it? Fortunately, it's fairly easy to test it, which is what the Starting Point Activity is designed to do.



Starting Point Activity

The idea that light picks up colour from coloured objects can be stated in the form of a hypothesis: If light picks up colour from coloured objects as it shines on them, then lights with different coloured bulbs will pick up the colour of the object they shine on. (For example, a blue light shining on a red apple will change colour to become red light.) Test this hypothesis by doing the following.

1. Arrange a set of bright-coloured objects around the classroom. Include a red object, a blue object, and a large white sheet of paper.
2. Obtain a red and a blue floodlight (or flashlights with red and blue filters).
3. Darken the classroom as much as possible.
4. Shine the red floodlight on each object and state the colour that each object appears to be.
5. Now shine the blue floodlight on each object and state the colour that each object appears to be.
6. Think about what you have observed. Is it possible for the colours that you see to come from the objects? If so, state evidence to support your view. If not, explain why not, and suggest a different source for the colours that you see. After you have studied this topic, come back and read your answer to this question. See if there is anything you wish to change.

Light can be reflected, absorbed, or transmitted by objects.

When you look at an object, you see it because light travels in a straight line from the object to your eyes. To trace the straight-line path that light travels, scientists use an arrow that shows the direction in which light is travelling. This arrow is called a **ray**. You will use diagrams that involve rays—rays diagrams—to help you understand and make predictions about the way light behaves.

ray: an arrow that shows the direction in which light is travelling

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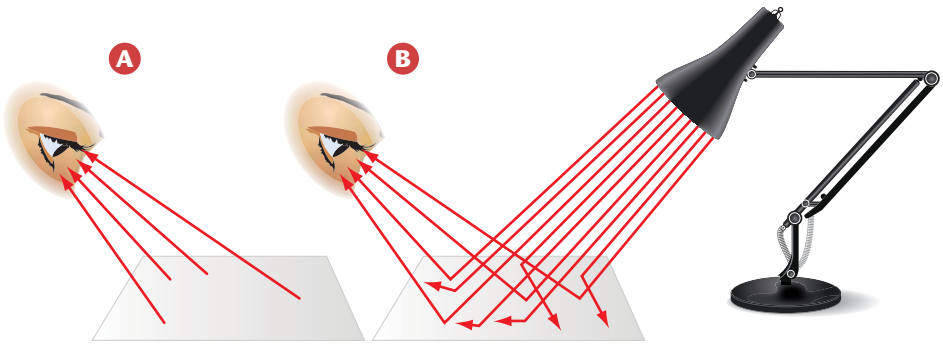
Reflection—Light Changes Direction

Reflection is the process in which light "bounces off" a surface and changes direction. You can use the ray model to show how reflection lets you see a white sheet of paper. Figure 4.6A shows light rays travelling from the paper to your eyes. The paper is not a source of light. Figure 4.6B shows light rays travelling from a source—a lamp—to the paper. When the light hits the paper, it "bounces off"—reflects—from the paper in all directions. Some of the light that reflects from the paper travels to your eyes. So you see the paper.

reflection: the process in which light "bounces off" the surface of an object and travels in another direction



▶ **Figure 4.6** For you to see an object as shown in (A), light must travel from that object to your eyes. For an object that is not a source of light, as shown in (B), light must travel from a source (such as a lamp or the Sun), to the object and reflect from it.

Absorption—Light Is Converted to Heat

You can see white paper because light is reflected, but you can read the black print on the paper because light is absorbed. **Absorption** is the process in which light energy remains in an object and is converted into heat. No light is reflected from an object that absorbs light. Black print on a page absorbs all the light that hits it. Each light ray ends on the black print. Figure 4.7 shows how light rays interact with print on a page. Notice that the rays that hit the "E" on the paper stop. No light reaches your eyes from the print. Your eyes and brain interpret the absence of light as "black."

absorption: the process in which light energy remains in the object that it hits, and the light energy is converted into heat

◀ **Figure 4.7** The black "E" appears black because the ink absorbs all of the light that hits it. No light reaches your eyes from the printed "E."

Transmission—Light Travels Through

When you hold a white piece of paper up to a light, you can see some light coming through the paper. **Transmission** is the process in which light penetrates an object and keeps travelling, allowing you to see the objects on the other side. Clear glass and plastic transmit nearly all of the light that hits them, but white paper transmits only some of the light. The light that is not transmitted by the paper is reflected or absorbed by it.

transmission: the process in which light travels through an object and continues travelling

Transparent, Translucent, and Opaque Objects

Some objects transmit all or most of the light that passes through them. Clear glass and clear plastic are examples. If light is transmitted directly through an object without any change in direction, the object is **transparent**.

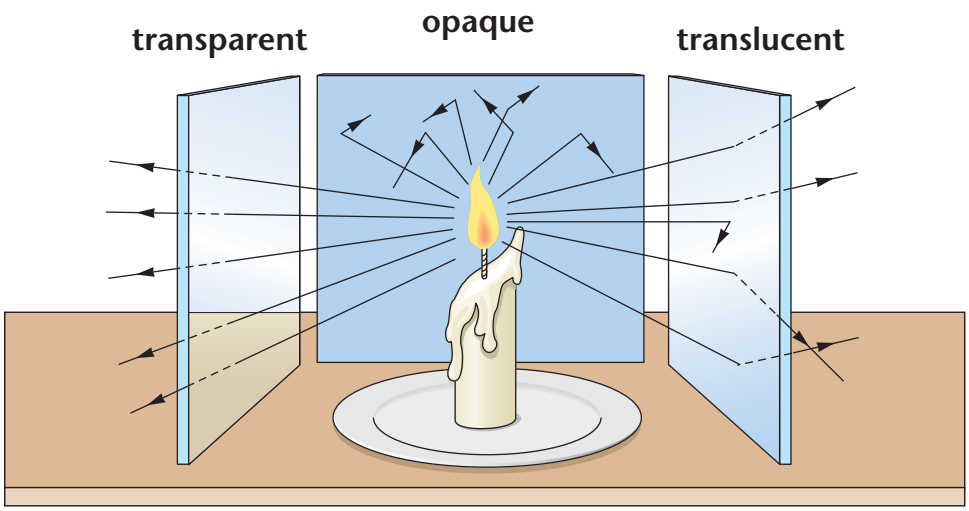
Some objects transmit only some of the light that passes through them. Waxed paper is an example. If light can penetrate an object but it is scattered in many different directions, the object is **translucent**. When you look at a translucent object, you can see light and sometimes some blurry shapes, but you cannot see a clear image on the other side.

Some objects don't transmit any light at all. Wood, books, and bodies are examples. If an object absorbs or reflects light only and no light penetrates it, the object is **opaque**. Figure 4.8 summarizes the meaning of transparent, translucent, and opaque.

transparent: A property of an object that allows light to penetrate it, making it possible to see objects from the other side.

translucent: A property of an object that allows light to pass through but scatters it in different directions.

opaque: A property of an object that will not allow any light to penetrate it.



◀ **Figure 4.8** Light rays travel straight through a transparent object. A translucent object scatters the light that travels through. No light travels through an opaque object.

LEARNING CHECK

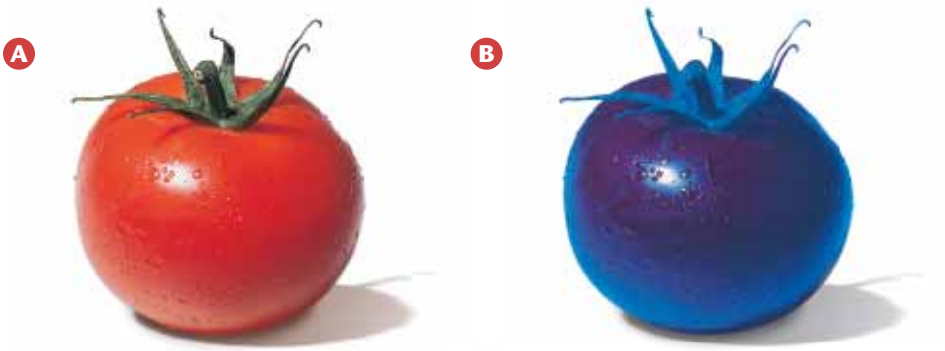
1. Use a flowchart to describe the three things that can happen to light when it hits an object.
2. Explain how a ray helps you describe the way light travels and what happens when it meets a material.
3. Sketch how a book would look if it were behind a sheet of **a)** clear plastic wrap, **b)** waxed paper, **c)** aluminum foil. Then classify each material as opaque, transparent, or translucent.

Objects can absorb some colours and reflect or transmit others.

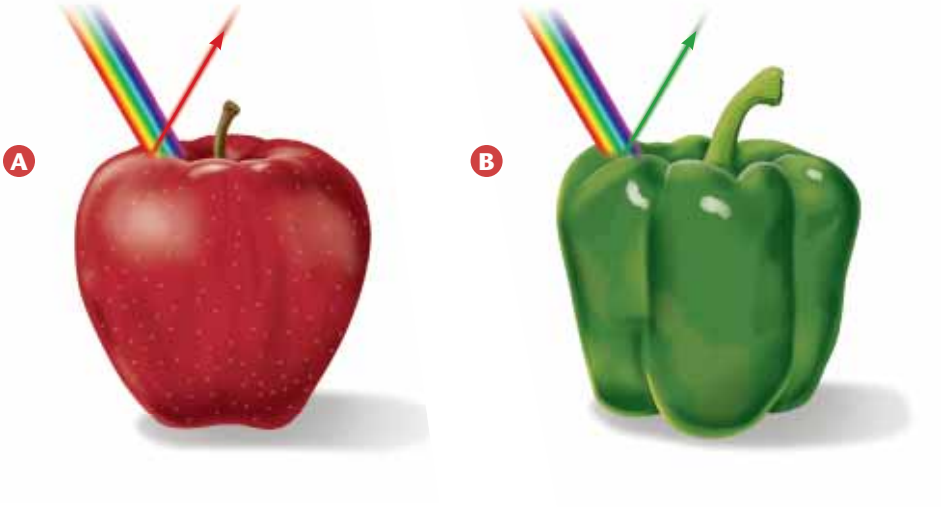
The Colour of an Opaque Object

What colour is the tomato in **Figure 4.9**? Under white light, the tomato looks red, but under blue light the tomato looks almost black. What does it mean for an object to "be" a certain colour? To answer this question, start with what you know about the way that light behaves when it hits opaque objects. As you know, opaque objects either absorb light or reflect light. In **Figure 4.9A**, white light is shining on the tomato. White light is a mixture of all of the colours (wavelengths) of visible light—including red. Only red light is travelling from the tomato to your eyes. So the tomato must be reflecting the red wavelengths of light and absorbing all the other colours.

What is happening in **Figure 4.9B**? The tomato can reflect only red light. Because no red light is shining on it, the tomato absorbs all of the light that reaches it and it appears almost black. **Figure 4.10** shows a diagram of the way the colour of an opaque object interacts with white light.



▶ **Figure 4.9** Under white light, the tomato looks like what you expect a tomato to look like. Under blue light, it looks more like a plum.

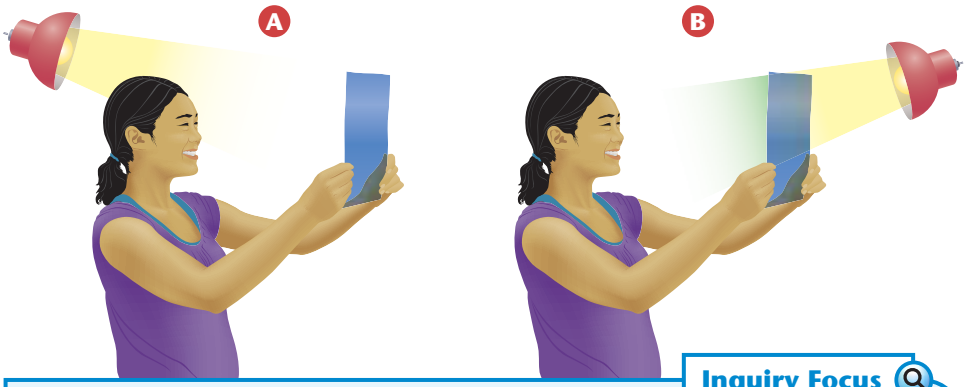


▶ **Figure 4.10** The colour of an object is determined by the colours that it absorbs and the colours that it reflects.

The Colour of a Transparent or Translucent Object

If you look at a piece of blue cellophane with white light shining on it, it looks blue. If you look at the same piece of blue cellophane with the white light shining from behind it, it still looks blue. How is light interacting with a transparent or translucent object that is coloured?

The only way that the cellophane in **Figure 4.11A** could look blue is if only blue light is reflecting from the cellophane. The only way that the cellophane in **Figure 4.11B** could look blue is if only blue light is transmitted through the cellophane. All other colours must be absorbed by the cellophane. For a transparent or translucent object to have a certain colour, it must absorb all other colours of light, as shown in **Figure 4.12**. It must also transmit and reflect the colour that is its particular colour.



◀ **Figure 4.11** The cellophane looks blue whether light is shining on it (A) or through it (B).

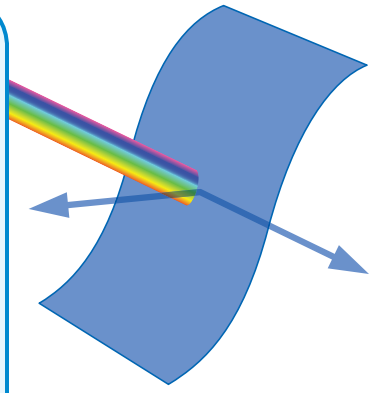
Inquiry Focus

Activity 4.2

SHINING THE SPOTLIGHT ON COLOUR

How does the colour of the light shining on an object affect its colour? Find out by doing these steps.

1. Write a word or draw a picture on white paper using a blue marking pen.
2. Predict whether the word or picture will appear more faint or more distinct under blue light instead of white light. Give reasons for your predictions.
3. Dim the lights in the room. Check your predictions by shining a blue spotlight on the paper with the blue writing or drawing. If your predictions didn't match your observations, explain what you think happened.



▲ **Figure 4.12** The cellophane absorbs every colour except blue. It transmits and reflects blue light. That's why we see it as blue.

LEARNING CHECK

1. Sketch a lemon and draw light rays to explain why it has the colour it does.
2. If you shine red light on a green pepper, what colour do you think the pepper will be? Draw light rays to explain your answer.

Inquiry Focus

Activity 4.3

EXPLORING THE PROPERTIES OF LIGHT

The path travelled by a ray of light is an important property of light. In this activity you will investigate this property. Then you can build a device that depends on this property in Part II.

Safety

Use the push pin and utility knife with extreme care. Always have the blade pointed away from you.

What You Will Need

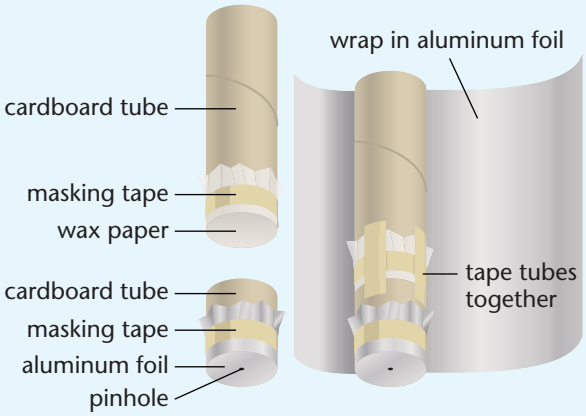
- cardboard tubing (4 cm to 8 cm in diameter and about 25 cm long)
- ruler
- utility knife
- translucent wax paper
- aluminum foil
- masking tape
- push pin

Part I: Demonstrate That Light Travels in a Straight Line

You have read that light travels in a straight line. Ray diagrams depend on this important property of light. So prove it! Design and carry out an experiment to demonstrate that light follows a straight-line path when it travels from a source.

Part II: Making a Pinhole Camera

1. A pinhole camera is an ancient invention that can form a picture (an image) of something without a lens and without film. Measure and mark the cardboard tubing 5 cm from one end. Cut off the end with the utility knife. (Your teacher might choose to cut the tubes ahead of time.)
2. Cover one end of the short tube with the aluminum foil. Tape the foil on the tube with masking tape. With the push pin, make a tiny hole in the centre of the foil.
3. Cover one end of the long part of the tube with wax paper and secure it with masking tape.
4. Connect the parts together as shown in the diagram. Cover the entire tube with aluminum foil and tape it on. This is your pinhole camera.



5. Find a very bright sunlit area or a very brightly lit room. Hold the open end of the camera up to one eye and close the other eye. Cup your hands around the end of the camera and your eye to keep out as much light as possible.
6. Look through the pinhole camera at some object. Describe and sketch what you see.

What Did You Find Out?

1. Explain how light travelling in a straight line could form the image that you saw in your pinhole camera. Use ray diagrams to help you show your ideas.

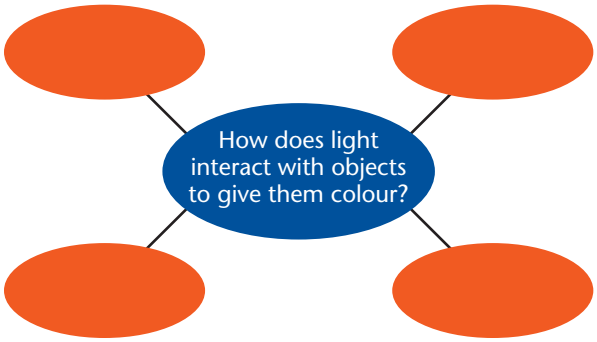
Topic 4.2 Review

Key Concept Summary

- Light can be reflected, absorbed, or transmitted by objects.
- Objects can absorb some colours and reflect or transmit others.

Review the Key Concepts

1. K/U Answer the question that is the title of this topic. Copy and complete the graphic organizer below in your notebook. Fill in four examples from the topic using key terms as well as your own words.



2. K/U For each object below, state whether white light that reaches the object will be transmitted, reflected, absorbed, or a combination of these possibilities.

3. C Use light rays to show and explain how a transparent object differs from a translucent object.

4. K/U List two examples of objects that are

a) opaque

b) transparent

c) translucent

5. T/I Describe the colour and appearance of an opaque object that absorbs all colours of light.

6. T/I Plants absorb light energy and convert it into chemical energy. If you shine only green light on a plant, do you think it will grow and convert the light into chemical energy? Explain your answer.

7. T/I If the walls in this picture were lit by red light instead of white light, what colours would the walls appear to be? Explain your answer.

8. A On a traffic light, the colours red, yellow, and green represent stop, caution, and go. Describe at least three other objects or devices that use colours for practical purposes.