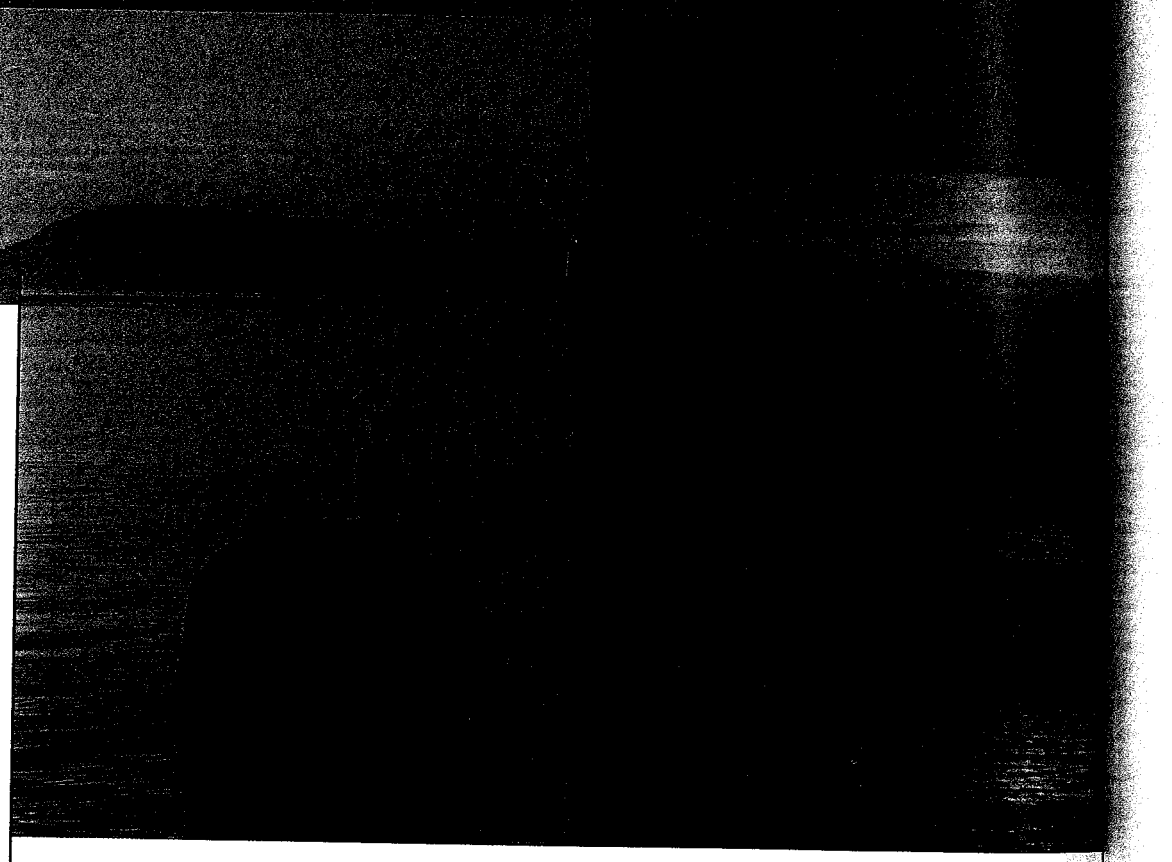
CHAPTER 10

Sources and Properties of Light



KEY IDEAS

- Light is produced by a variety of sources, both natural and artificial.
- Light may be reflected, transmitted, or absorbed, depending on the material that it strikes.
- Visible light is a part of the energy that comes from the Sun.
- The visible and invisible parts of radiation from the Sun make up the electromagnetic spectrum.

LEARNING TIP

Before reading this chapter, make a note of the headings and subheadings. Ask yourself, "What do I already know about this topic? What questions do I have about this topic?"

The rising and setting of the Sun are regular occurrences that we often take for granted. Most of our daily activities occur between sunrise and sunset so we can use light from the Sun. After sunset, we use other sources of light for our activities.

The Sun is so bright that it is dangerous to look at, yet it is the most important source of light for everything on Earth. Thinking about the Sun reveals a lot about the behaviour of light. Sunlight produces shadows in a forest and a city. Sunlight shines through the atmosphere and through windows, but not through bricks or wood. Sunlight reflects brightly off mirrors and water but not off asphalt. Why does sunlight, and all other light, behave in these ways?

In this chapter, you will explore the sources, properties, and characteristics of light. As well, you will learn how light from the Sun is used as a source of energy.

Light Energy and Its Sources

10.1

What is light? Light is not something you can touch or taste. It does not have any mass. But you can see light, and you can observe its effects on matter. For example, a penny put in sunlight will get warmer than a penny placed in the shade. The penny put in sunlight gains energy from the light. Based on this observation, we can define **light** as a form of energy that can be detected by the human eye.

You can learn more about light by looking carefully around you. In a room lit by electric light, for example, you can see the light energy that travels directly from the electric light to your eyes. What about other objects in the room? How can you see them? The light energy from the electric light must spread throughout the room. Some of it bounces off objects and then travels to your eyes, enabling you to see objects and people in the room. **Figure 1** shows how light reaches your eyes.

LEARNING TIP

Identifying key words helps readers determine the most important concepts in a chapter. To help you determine key words, look for words that are highlighted, repeated, and used in headings.

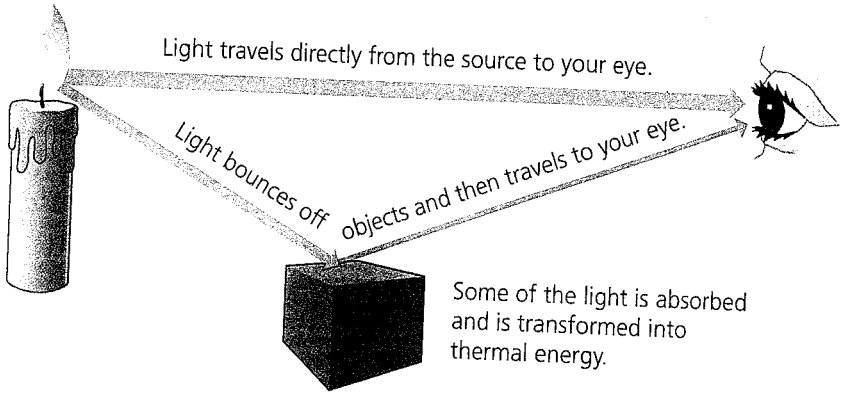


Figure 1
Light energy travels directly and indirectly to your eyes.

Sources of Light and Reflectors of Light

Light energy comes from many different sources, both natural and artificial. The Sun is the most important natural source of light. Artificial sources of light are created by people. Objects that emit (give off) energy in the form of light are said to be **luminous**. For example, the Sun is luminous, and so is a burning candle. Objects that do not emit light, but only reflect light from other sources, are said to be **nonluminous**. Most things—this book, your desk, your classmates—are nonluminous. Even the Moon is nonluminous—it does not emit light. We see the Moon because it reflects light from the Sun.

LEARNING TIP

Active readers pose questions to guide their reading. Read this section and try to answer these questions: "Which light sources are efficient sources of light? Which light sources are inefficient sources of light?"

In luminous objects, the input energy transforms into light energy. Common forms of input energy are chemical energy, electrical energy, nuclear energy, and thermal energy.

When designing a light source, engineers consider not only the brightness, location, attractiveness, and cost of the light source. They also consider how effectively the light source transforms the input energy into light energy.

Light from Incandescence

Things that are extremely hot become luminous. At high temperatures, they begin to emit light. The process of emitting light because of high temperatures is called **incandescence.** In incandescent light sources, a large amount of the input energy becomes thermal energy. Therefore, these light sources are not efficient.

In an incandescent light bulb, electrical energy transforms into heat and light energy (**Figure 2**). Electricity passing through a fine metal wire (the tungsten filament) makes the wire very hot when the bulb is turned on.

A kerosene lamp can provide enough light to read by (**Figure 3**). The chemical energy in the kerosene fuel transforms into heat and light energy.

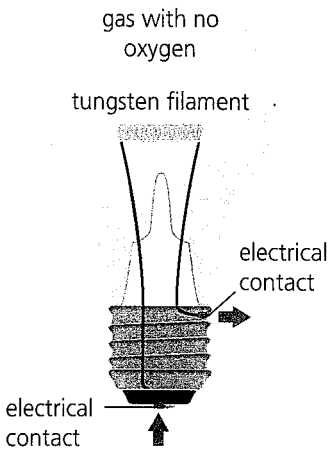


Figure 2
In an incandescent light bulb, electricity passes through a fine metal wire. The wire becomes very hot when the bulb is turned on. (The direction of the electricity is shown by the arrows.)

Figure 3
The chemical energy in kerosene fuel transforms into heat and light energy.

Thermal energy can heat a metal to such a high temperature that it emits light. This light ranges from dull red to yellow to white and blue-white as the metal gets hotter. The colour of the emitted light indicates when the molten metal is ready to be poured.

Light from Phosphorescence

Certain materials, called phosphors, give off light for a short time after you shine a light on them. They store the energy and then release it gradually as light energy. The process of emitting light for a short time after receiving energy from another source is called **phosphorescence**. The colour of the light and the length of time it lasts depend on the material used. This is a good way to make light switches that glow in the dark. **Figure 4** shows a phosphorescent light source.

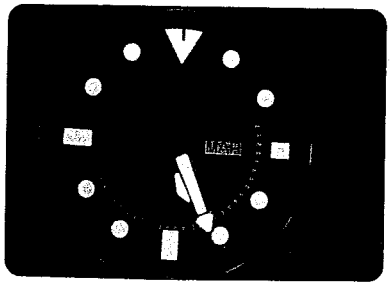


Figure 4
The painted luminous dials on some watches and clocks are phosphorescent.

Light from Electric Discharge

When electricity passes through a gas, the gas particles can emit light. The process of emitting light because of electricity passing through a gas is called **electric discharge**.

Lightning is an example of electric discharge in nature. The electricity discharges through the air, from one cloud to another or from a cloud to Earth. Some artificial light sources make use of electric discharge. Electricity is passed through tubes filled with gases, such as neon. The electricity causes the gases to emit light (**Figure 5**). Neon gas gives off a reddish-orange light. Sodium vapour gives off a yellowish light. Other gases emit other colours of light.

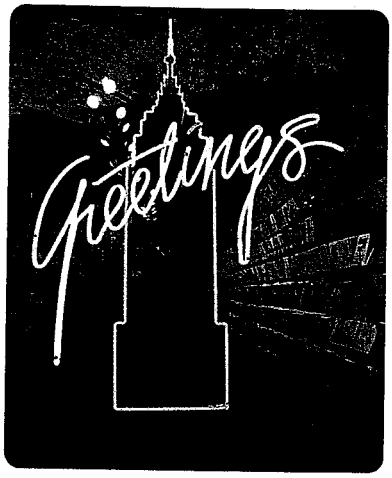


Figure 5
This artificial light source works because of electric discharge.

Light from Fluorescence

Fluorescence is the process of emitting light while receiving energy from another source. Fluorescent tubes are used in schools, offices, and homes. Fluorescent tubes use electric discharge and phosphorescence (**Figure 6**). Electricity passing along the tube causes particles of mercury vapour to emit ultraviolet (UV) energy. Since UV energy is invisible, however, it does not help you see. The UV energy is absorbed by a phosphor coating on the inside of the tube. The coating emits light that you can see. After the light is turned off, the phosphors emit light for a very brief time, much less than a second.

LEARNING TIP

Diagrams are important to reader comprehension. Study **Figure 6** and make connections to the information provided in the text.

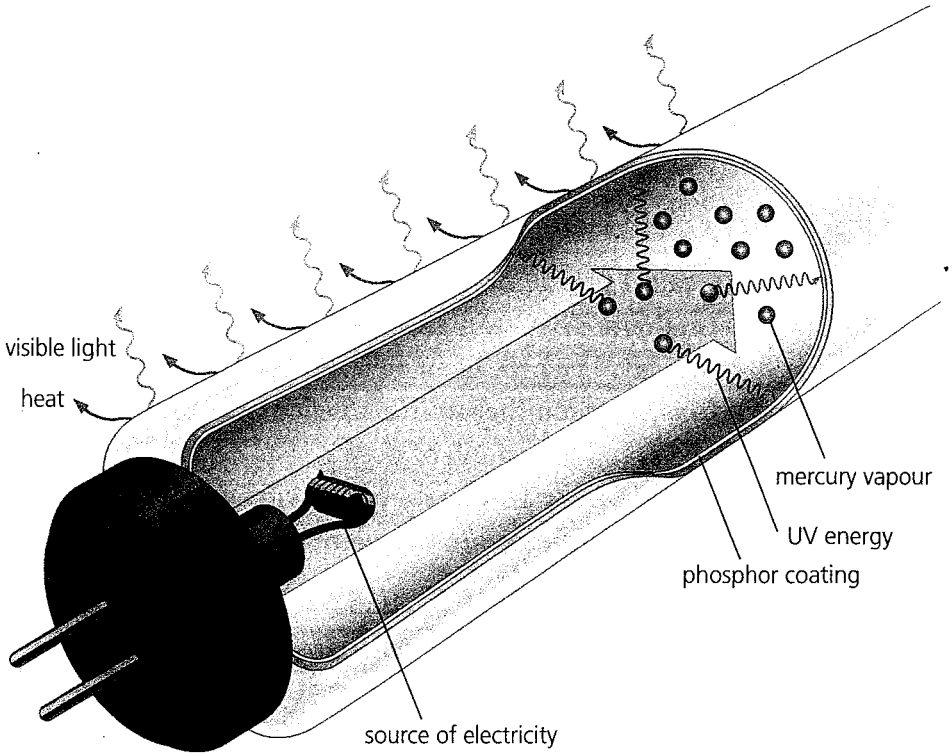


Figure 6
A fluorescent light source. Fluorescent tubes do not produce as much heat as incandescent light bulbs.

Light from Chemiluminescence

LEARNING TIP

Pause and think. What conclusions did you draw about light sources that are efficient sources of light, and those that are inefficient sources of light?

Chemiluminescence is the process of changing chemical energy into light energy with little or no change in temperature.

Safety lights, often called glowsticks or light sticks, produce light by chemiluminescence. In these lights, a thin wall separates two chemicals (**Figure 7**). When the wall is broken, the chemicals mix and react to produce a light until the chemicals are used up.

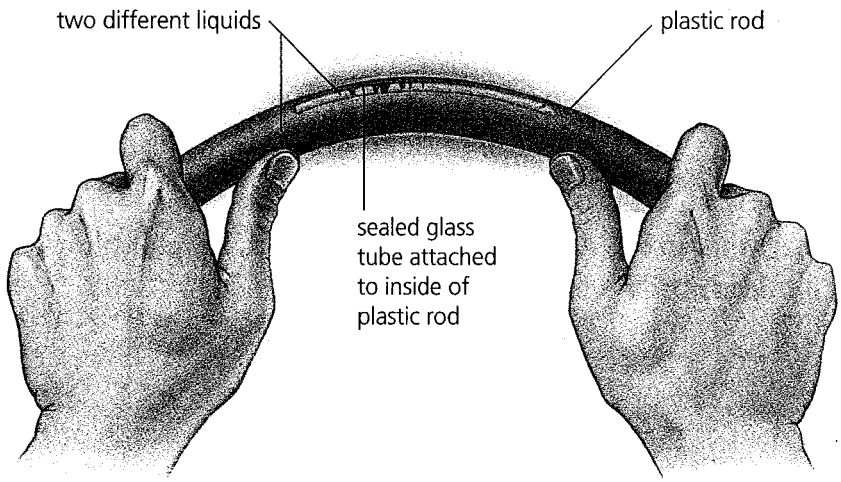


Figure 7
Light sticks are chemiluminescent light sources.

Light from Bioluminescence

Some living things, such as the fish in **Figure 8**, can make themselves luminous using a chemical reaction similar to chemiluminescence. This reaction is called **bioluminescence.** Fireflies and glow-worms are bioluminescent, as are some types of fish, squid, bacteria, and fungi.

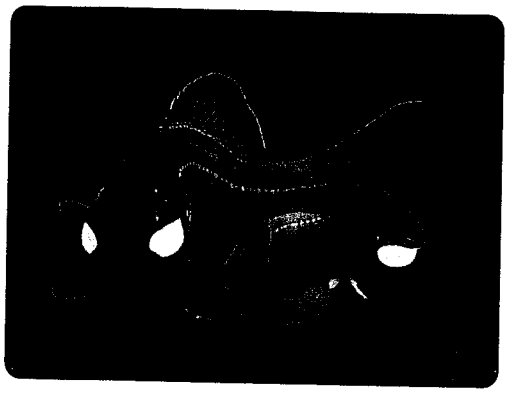


Figure 8
Many organisms that live deep in the ocean are bioluminescent. Scientists are not sure why so many species glow. Perhaps it allows members of the same species to find each other.

DID YOU KNOW ?

Firefly Chemistry

The "fire" of a firefly is bioluminescence. It is caused by a chemical reaction between oxygen and several other chemicals in special cells called photocytes. (A similar type of reaction is used to produce the chemiluminescence in glowsticks.) The flashing of fireflies is a mating signal between males and females. The males fly around and flash, while the females sit in trees and flash back.

10.1 CHECK YOUR UNDERSTANDING

1. Which of the following are luminous?
   (a) a campfire
   (b) the Moon
   (c) a hot toaster filament
2. Make flow charts to illustrate the process that each luminous object uses to emit light and the type of energy that is transformed into light energy.
   (a) the lights in your home
   (b) a lit match
   (c) car headlights
   (d) Day-Glo paints and fabrics
3. Explain, in your own words, the difference between a phosphorescent light source and a fluorescent light source.
4. Describe how a flashlight can be luminous. Describe how it can also be nonluminous.
5. While cycling, your body's efficiency is about 20 %. This means that your body uses about 20 % of its available energy for cycling. The remaining 80 % becomes heat. Incandescent bulbs have an efficiency of about 5 %, fluorescent tubes about 20 %.
   (a) Why does a bright incandescent bulb get much hotter than a bright fluorescent tube?
   (b) Why do people not always use the most energy-efficient type of lighting? What other factors could affect their choice of lighting?
6. What kind of light source would be safest to use in buildings or mines that might be filled with explosive gas?

PERFORMANCE TASK

What source(s) of light might be used in the optical device you chose for the Performance Task? What source of light is best for this device?