18.5 Sources of Light

Reading Focus

Key Concepts

- What are the six common sources of light?
- How does each type of light source generate light?

Vocabulary

- luminous
- incandescent
- fluorescence
- phosphor
- laser
- coherent light

Reading Strategy

Sequencing Copy and complete the flowchart below. As you read, pick two other light sources and complete a similar flowchart showing how each source generates light.

Incandescent Bulb

Electrons flow through filament.

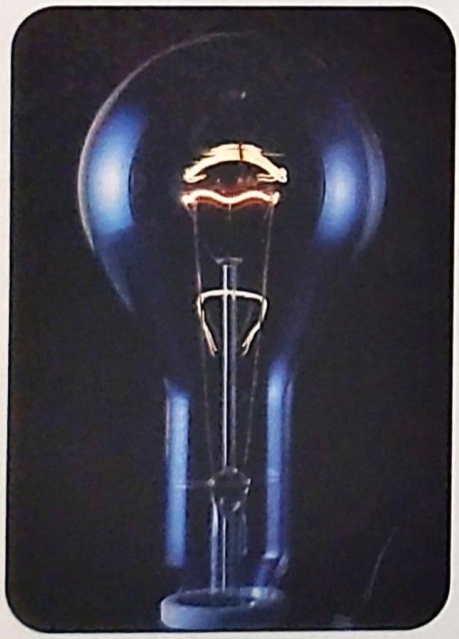
↓

a. ____?____

↓

Filament radiates light.

Figure 27 An incandescent bulb contains a filament. As electrons flow through the filament, the filament gets hot and emits light. **Formulating Hypotheses** *Why is a 100-watt bulb generally brighter than a 75-watt bulb?*



As sunlight fades toward the end of the day, objects around you become less and less visible. When the sun has completely set, you can no longer see your surroundings. Objects are invisible in the dark because no light is available to reflect off them. But some things, such as flashlights and fireflies, produce their own light. Objects that give off their own light are **luminous.** The sun is luminous, as are all light sources.

Common light sources include incandescent, fluorescent, laser, neon, tungsten-halogen, and sodium-vapor bulbs. Each type of bulb produces light in a different way.

Incandescent Light

The light produced when an object gets hot enough to glow is **incandescent.** Figure 27 shows an incandescent light bulb. Inside, you can see the filament, a thin coil of wire stretched between two thicker wires. **When electrons flow through the filament of an incandescent bulb, the filament gets hot and emits light.**

The filaments in incandescent light bulbs are made of a substance called tungsten. Incandescent light bulbs are filled with a mixture of nitrogen gas and argon gas at very low pressure. These gases do not react with the filament as oxygen would, and so the filament lasts longer. Incandescent bulbs give off most of their energy as heat, not light.

Fluorescent Light

In a process called **fluorescence** (floo uh RES uns), a material absorbs light at one wavelength and then emits light at a longer wavelength. A **phosphor** is a solid material that can emit light by fluorescence. **Fluorescent light bulbs emit light by causing a phosphor to steadily emit photons.** A fluorescent bulb, such as the one in Figure 28, is a glass tube that contains mercury vapor. Inside, the glass is coated with phosphors.

When electric current flows through a fluorescent bulb, small pieces of metal called electrodes heat up and emit electrons. The electrons hit atoms of the mercury vapor, causing the mercury atoms to emit ultraviolet rays. The ultraviolet rays strike the phosphor coating on the inside of the tube and the atoms emit visible light.

You may have noticed that office buildings and schools use mostly fluorescent lights. Fluorescent tubes do not get as hot as incandescent bulbs because they emit most of their energy as light. This means that they use energy very efficiently. One 18-watt fluorescent tube provides the same amount of light as a 75-watt incandescent bulb, and the fluorescent tube lasts ten times longer.

Reading Checkpoint *What happens during fluorescence?*

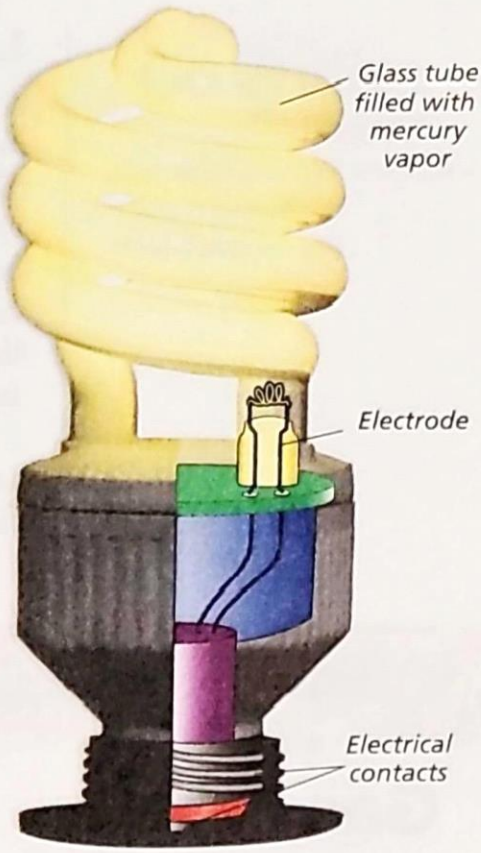


Figure 28 The electrodes in a fluorescent bulb emit electrons that cause the mercury atoms to emit ultraviolet rays. These rays cause the phosphor coating to emit light.

Quick Lab

Comparing Fluorescent and Incandescent Light

Materials

spectroscope, clear incandescent bulb, fluorescent bulb, colored pencils

Procedure

1. Turn on a clear, incandescent bulb. **CAUTION** *Incandescent bulbs get quite hot after they have been on for some time.* Observe the spectrum of the light coming from the incandescent bulb through a spectroscope.
2. Use colored pencils to draw this spectrum. Label the source of the spectrum.
3. Repeat Steps 1 and 2 with a fluorescent bulb.

Analyze and Conclude

1. **Comparing and Contrasting** How do the spectra produced by incandescent and fluorescent lights compare?
2. **Drawing Conclusions** During fluorescence, electrons absorb energy and move to specific higher energy levels. As they move back to a lower energy level, they release energy in the form of light. How does this fact help explain the appearance of the spectrum of fluorescent light?

Laser Light

A **laser** is a device that generates a beam of coherent light. The word *laser* stands for *l*ight *a*mplification by *s*timulated *e*mission of *r*adiation. **Laser light is emitted when excited atoms of a solid, liquid, or gas emit photons.** Light in which waves have the same wavelength, and the crests and troughs are lined up, is **coherent light.** A beam of coherent light doesn't spread out significantly from its source, so the light has a relatively constant intensity. The energy it carries may be focused on a small area.

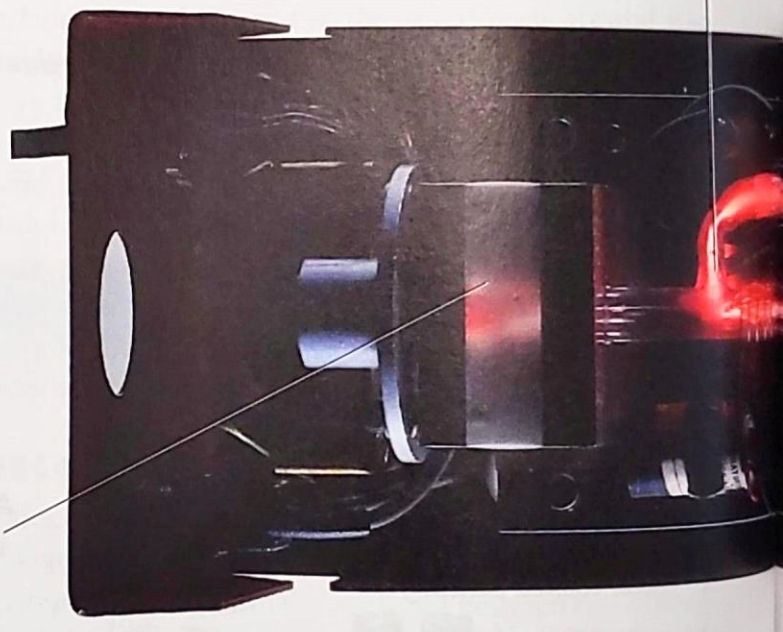
Lasers can cut through metals and make computer chips. Surgeons use lasers to cut or repair damaged tissue. Lasers carry information through optical fibers. Laser light is used to measure distances precisely.

DK HOW It Works

Gas Laser

Laser light is produced by exciting the atoms of a solid, liquid, or gas so that they emit photons. Some of these photons collide with other excited atoms and stimulate the emission of more photons. Eventually some photons are released as an intense beam of light. The gas laser shown here uses a mixture of helium and neon gases. **Interpreting Photographs** ***How does a laser produce coherent light?***

A Gas mixture Helium and neon gases are held in a sealed glass tube. Additional tubes, containing electrodes, are attached at the sides.



Fully reflective mirror *Photons bounce between this and a second, semi-reflective mirror.*

Using lasers
Hand-held devices incorporating lasers are used in stores for reading bar codes. In the home, they are at the heart of many devices such as DVD and CD players.

Laser beam scans the label.

Neon Light

A big city at night is likely aglow in neon lights. **Neon lights emit light when electrons move through a gas or a mixture of gases inside glass tubing.** Many lights called neon lights contain gases other than neon. Often, other gases including helium, argon, and krypton are used in neon lights. Helium gas gives off a pink light. A mixture of argon gas and mercury vapor produces greenish-blue light. Krypton gas produces a pale violet light. Pure neon emits red light when electrons flow through the gas. Each kind of gas emits photons of different energies, and therefore different colors. The different photons emitted combine to give each glowing gas a distinctive color. The color of glass used to make the tube can also affect the color of the light.

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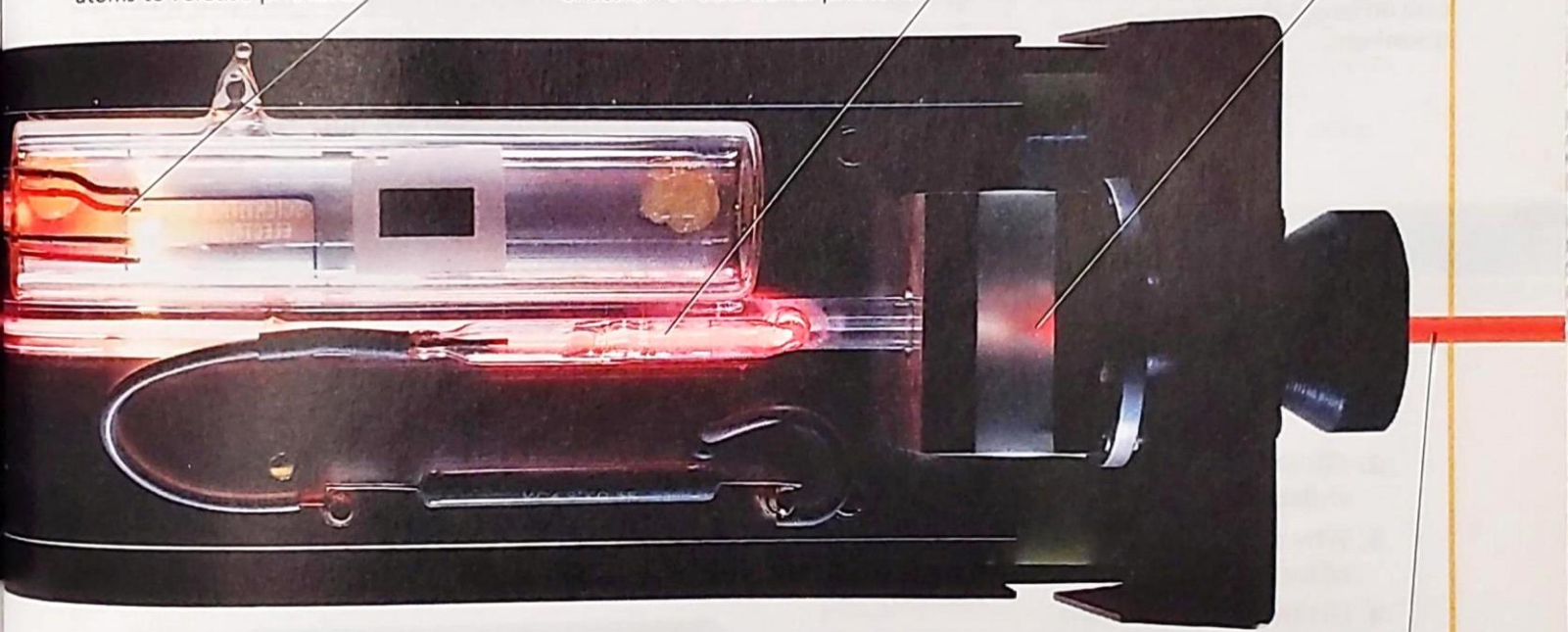
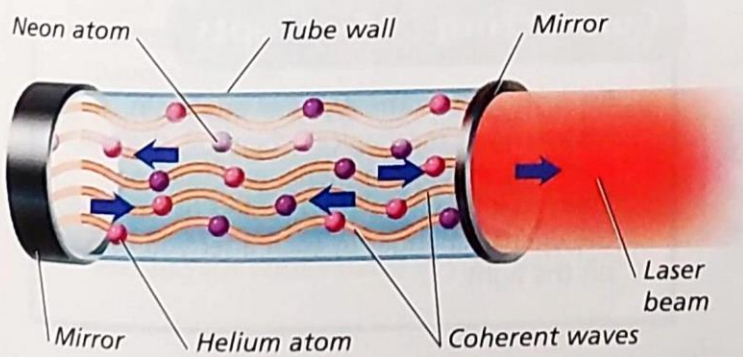
B Electrode An electric current passes between this electrode and its twin on the other side of the tube, raising gas atoms to an excited state. This causes the atoms to release photons.

C Photon multiplication The photons begin to bounce back and forth off the mirrors at either end. Some hit other excited atoms, stimulating the emission of additional photons.

D Semi-reflective mirror Because it is only semi-reflective, this mirror reflects most of the photons but lets a few of them through.





E Laser beam A straight, narrow, intense beam of coherent light emerges at this end.

Coherent light
The waves in laser light all have the same wavelength and direction of travel, and their peaks coincide. Light with these properties is called coherent light.

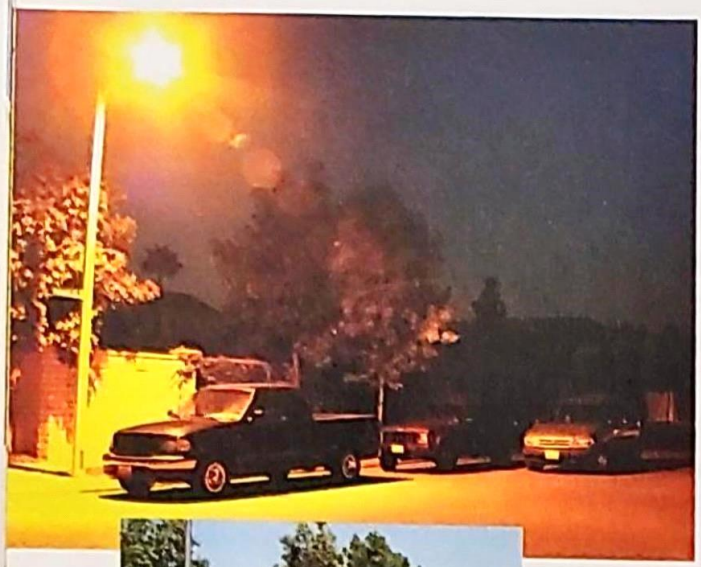


Figure 29 The yellow color of sodium-vapor light makes objects look different than they look in sunlight.

Sodium-Vapor Light

Sodium-vapor lights contain a small amount of solid sodium, as well as a mixture of neon and argon gases. **As electric current passes through a sodium-vapor bulb, it ionizes the gas mixture. The mixture warms up and the heat causes the sodium to change from a solid into a gas.** The current of electrons knocks electrons in sodium to higher energy levels. When the electrons move back to lower energy levels, the sodium atoms emit light. Sodium-vapor lights are energy efficient and give off very bright light. Many streets and parking lots are illuminated with sodium-vapor lights. Figure 29 shows how sodium-vapor light produced with neon and argon can alter the color of the objects it illuminates.

Tungsten-Halogen Light

Tungsten-halogen light is produced in much the same way as incandescent light. But unlike incandescent lights, a tungsten-halogen's bulb has a small amount of a halogen gas, such as iodine, bromine, or fluorine. **Inside a tungsten-halogen bulb, electrons flow through a tungsten filament. The filament gets hot and emits light.** The halogen gas reduces wear on the filament, so tungsten-halogen bulbs last longer than incandescent bulbs. The bulb of a tungsten-halogen light is made of quartz, because quartz has a high melting point. If glass were used, it would start to melt when the bulb got hot.

Section 18.5 Assessment

Reviewing Concepts

1. Name six common sources of light.
2. Describe how each type of bulb produces visible light.
3. Why are fluorescent light bulbs often used in office buildings and schools?
4. List three uses for lasers.
5. How are tungsten-halogen bulbs different from incandescent bulbs?

Critical Thinking

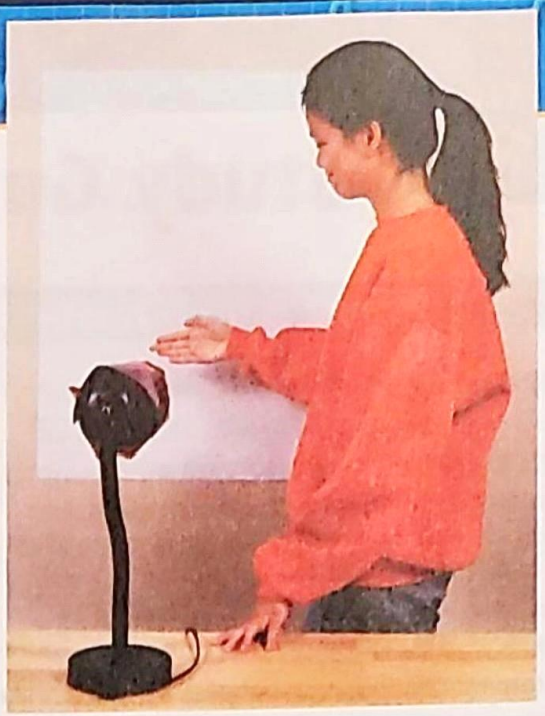
6. **Comparing and Contrasting** How are the six main types of lights similar? How are they different?
7. **Applying Concepts** Why do some bulbs heat up more than others?
8. **Formulating Hypotheses** A friend rubs a compact fluorescent bulb on her shirt on a dry day, and the bulb lights up for a moment. Propose a hypothesis to explain why.

Connecting Concepts

Energy Review the types of energy in Section 15.1: mechanical, chemical, thermal, electrical, electromagnetic, and nuclear. Then pick two light sources and describe the energy changes in each after you turn on the light.

Exploration Lab

Mixing Colored Lights



What is color? How many different colors can be formed from a combination of only three colors? In this exploration, you will examine what happens when lights of three different colors are mixed.

Problem How can you produce a range of colors from three lights of different colors?

Materials

- sources of red, blue, and green light
- tape
- large sheet of white paper

Skills Observing

Procedure

1. On a separate sheet of paper, make a copy of the data table shown.

Data Table

Light Sources	Colors of Lights	Colors of Shadows
Red only		
Blue only		
Green only		
Red and blue		
Red and green		
Blue and green		
Red, blue, and green		

2. Dim the room lights. Turn on the red light source and shine it on a large sheet of white paper. In your data table, record the colors you observe on the paper. **CAUTION** *Do not touch lamps when they are on. They may be hot.*
3. Place your hand between the light source and the paper as shown. Record the color of your hand's shadow.
4. Repeat Steps 2 and 3 with the blue and then with the green light source.
5. Now turn on the red and blue light sources and allow their beams to partially overlap. Record your observations in your data table.
6. Place your hand in the overlapping beams of light. Note the colors of any shadows that your hand makes. Record your observations.
7. Repeat Steps 5 and 6 with the red and green light sources. Then repeat Steps 5 and 6 with the blue and green light sources.
8. Turn on all three light sources and allow their beams to overlap. Record your observations.
9. Place your hand in the overlapping red, green, and blue beams. Note the colors of any shadows that your hand makes on the white paper. Record your observations.

Analyze and Conclude

1. **Observing** What happened when two colored lights overlapped?
2. **Analyzing Data** How did the combination of two colored lights produce the shadows you observed?
3. **Applying Concepts** Explain how combining three colored lights produced the colors you observed.
4. **Drawing Conclusions** From the shadows you observed when using three colored lights, what can you conclude about how colors of light combine? Explain your answer.

Go Further Examine the effects of red, green, and blue lights on the appearance of familiar objects, such as red apples and green grass. Prepare a report explaining your observations and present the report to the class.

CHAPTER 18

Study Guide

18.1 Electromagnetic Waves

Key Concepts

- Electromagnetic waves are produced when an electric charge vibrates or accelerates.
- Electromagnetic waves can travel through a vacuum as well as through matter. The speed of light in a vacuum, c, is 3.00×10^8 m/s.
- Electromagnetic waves vary in wavelength and frequency.
- Electromagnetic radiation behaves sometimes like a wave and sometimes like a stream of particles.
- Light spreads out as it moves away from its source.

Vocabulary

electromagnetic waves, *p. 533;* electric field, *p. 533;* magnetic field, *p. 533;* electromagnetic radiation, *p. 533;* photoelectric effect, *p. 537;* photons, *p. 537;* intensity, *p. 538*

18.2 The Electromagnetic Spectrum

Key Concepts

- The electromagnetic spectrum includes radio waves, infrared waves, visible light, ultraviolet rays, X-rays, and gamma rays.
- Electromagnetic waves are used in communications, medicine, and industry.

Vocabulary

electromagnetic spectrum, *p. 540;* amplitude modulation, *p. 541;* frequency modulation, *p. 541;* thermograms, *p. 543*

18.3 Behavior of Light

Key Concepts

- Materials can be transparent, translucent, or opaque.
- When light strikes a new medium, it can be reflected, absorbed, or transmitted.

Vocabulary

transparent, *p. 546;* translucent, *p. 547;* opaque, *p. 547;* image, *p. 547;* regular reflection, *p. 547;* diffuse reflection, *p. 547;* mirage, *p. 548;* polarized light, *p. 548;* scattering, *p. 549*

18.4 Color

Key Concepts

- As white light passes through a prism, shorter wavelengths refract more than longer wavelengths, and the colors separate.
- The color of any object depends on what the object is made of and on the color of light that strikes the object.
- The primary colors of light are red, green, and blue.
- The primary colors of pigments are cyan, yellow, and magenta.

Vocabulary

dispersion, *p. 551;* primary colors, *p. 552;* secondary color, *p. 552;* complementary colors of light, *p. 552;* pigment, *p. 553;* complementary colors of pigments, *p. 553*

18.5 Sources of Light

Key Concepts

- Common light sources include incandescent, fluorescent, laser, neon, tungsten-halogen, and sodium-vapor bulbs.
- Each light source produces light in a different way.

Vocabulary

luminous, *p. 558;* incandescent, *p. 558;* fluorescence, *p. 559;* phosphor, *p. 559;* laser, *p. 560;* coherent light, *p. 560*

Thinking Visually

Web Diagram Copy the web diagram below onto a sheet of paper. Use information from the chapter to complete the diagram.