

**Stars, Galaxies, and the Universe** ▪ *Guided Reading and Study*

# Telescopes

*This section describes electromagnetic radiation. It also explains how different types of telescopes work and where they are located.*

## Use Target Reading Skills

*The first column in the chart lists key terms in this section. Write what you know about the key term in the second column. As you read, write a definition of the key term in your own words in the third column. Some examples are done for you. Connecting what you already know about key terms helps you to remember them.*

Key Term	What You Know	Definition
Telescope	You use it to see distant objects better.	Device that makes objects far away seem closer
Electromagnetic radiation	You can see only some types of it.	Energy in the form of waves that moves through space
Visible light		
Wavelength		
Spectrum		
Optical telescope		
Refracting telescope		
Convex lens		
Reflecting telescope		
Radio telescope		
Observatory		

**Stars, Galaxies, and the Universe**

**Stars, Galaxies, and the Universe** ▪ *Guided Reading and Study*

**Telescopes** *(continued)*

**Electromagnetic Radiation**

1. What is electromagnetic radiation?

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2. The light you see with your eyes is called \_\_\_\_\_.

3. The distance between the crest of one wave and the crest of the next wave is called a(n) \_\_\_\_\_.

4. A range of light of different colors and different wavelengths is called a(n) \_\_\_\_\_.

5. What colors form the spectrum of visible light?

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6. What wavelengths are included in the electromagnetic spectrum?

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**Types of Telescopes**

7. What do telescopes collect and focus?

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8. What is a convex lens?

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9. Complete the table to compare and contrast different types of telescopes.

<b>Telescopes</b>	
<b>Type</b>	<b>Description</b>
Refracting telescope	a.
Reflecting telescope	b.
Radio telescope	c.

d. How is a radio telescope different from both a refracting and a reflecting telescope?

\_\_\_\_\_

\_\_\_\_\_

e. How is a radio telescope similar to both a refracting and a reflecting telescope?

\_\_\_\_\_

\_\_\_\_\_

10. Which telescope uses convex lenses? \_\_\_\_\_

11. The largest visible light telescopes are now all \_\_\_\_\_.

**Observatories**

12. A building that contains one or more telescopes is called a(n) \_\_\_\_\_.

13. Why have astronomers built the largest optical telescopes on the tops of mountains?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

14. Why have astronomers placed telescopes in space?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

15. Why can the Hubble Space Telescope make very detailed images in visible light?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



**Stars, Galaxies, and the Universe** ▪ *Section Summary*

# Telescopes

## Key Concepts

- What are the regions of the electromagnetic spectrum?
- What are telescopes and how do they work?
- Where are most large telescopes located?

Ancient peoples often gazed up in wonder at the many points of light in the night sky. But they could see few details of these objects with their eyes alone. It was not until the invention of the telescope in 1608 that people could observe objects in the sky more closely. Recall that a **telescope** is a device built to observe distant objects by making them appear closer.

Light is a form of **electromagnetic radiation**. Scientists call the light you can see **visible light**. The distance between the crest of one wave and the crest of the next is called a **wavelength**. Visible light has very short wavelengths.

If you shine white light through a prism, the light spreads out to make a range of different colors with different wavelengths, called a **spectrum**. **The electromagnetic spectrum includes the entire range of radio waves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays.**

**Telescopes are instruments that collect and focus light and other forms of electromagnetic radiation.** A telescope that uses lenses or mirrors to collect and focus visible light is called an **optical telescope**. The two major types of optical telescopes are refracting telescopes and reflecting telescopes. A **refracting telescope** uses convex lenses to gather and focus light. A **convex lens** is a piece of transparent glass, curved so that the middle is thicker than the edges. In 1668, Isaac Newton built the first reflecting telescope. A **reflecting telescope** uses a curved mirror to collect and focus light.

Devices used to detect radio waves from objects in space are called **radio telescopes**. Most radio telescopes have curved, reflecting surfaces. As with optical telescopes, the larger a radio telescope is, the more radio waves it can collect. Other telescopes are designed to detect infrared radiation, ultraviolet radiation, X-rays, or gamma rays.

An **observatory** is a building that contains one or more telescopes. **Many large observatories are located on mountaintops or in space.** The sky on some mountaintops is clearer and has less light pollution. Today, many large optical telescopes are equipped with computer systems that correct images for problems such as telescope movement and changes in the atmosphere.

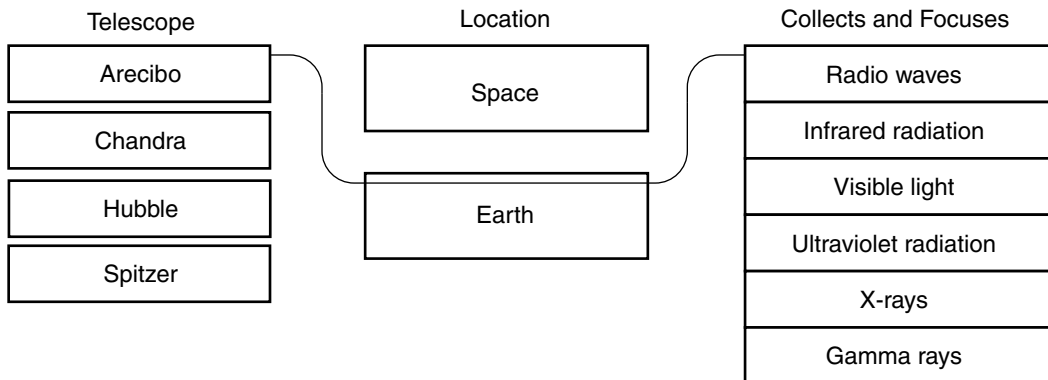
Most ultraviolet radiation, X-rays, and gamma rays are blocked by Earth's atmosphere. To detect these wavelengths, astronomers have placed telescopes in space. Some space telescopes also detect visible light or infrared radiation, since Earth's atmosphere interferes with the transmission of these forms of radiation.

**Stars, Galaxies, and the Universe** ▪ *Review and Reinforce*

# Telescopes

## Understanding Main Ideas

For each tool on the left, draw a line that connects it with its function. Then continue the same line to connect the tool and function with the type of electromagnetic radiation that the tool uses. Some functions and types of electromagnetic radiation will have more than one line connecting them. The first one is done for you.



1. What is electromagnetic radiation?

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## Building Vocabulary

Match each term with its definition by writing the letter of the correct definition in the right column on the line beside the term in the left column.

- |                      |  |
|----------------------|--|
| ___ 2. telescope     | a. a building that contains one or more telescopes                                   |
| ___ 3. spectrum      | b. the portion of the electromagnetic spectrum that humans can see                   |
| ___ 4. observatory   | c. white light shining through a prism spreads out to form this                      |
| ___ 5. wavelength    | d. a device built to observe distant objects by making them appear closer            |
| ___ 6. visible light | e. a piece of transparent glass, curved so that the middle is thicker than the edges |
| ___ 7. convex lens   | f. the distance between the crest of one wave and the crest of the next wave         |

**Stars, Galaxies, and the Universe** ▪ *Enrich***Seeing Without Light**

Some of the most interesting objects in the sky, such as new stars, are hidden behind the huge clouds of gas and dust that lie among the stars.

Astronomers can now “see” through these barriers by using parts of the electromagnetic spectrum that have wavelengths longer than those of visible light.

An astronomer deciding which part of the electromagnetic spectrum to use must deal with at least two problems:

- **Some wavelengths don’t pass through the atmosphere:** Earth’s atmosphere allows visible light, radio waves, and some infrared waves to pass through, but stops X-rays, gamma rays, and most ultraviolet light. Astronomers who want to use wavelengths other than visible light, infrared, and radio waves must obtain their observations from telescopes in space.
- **Some wavelengths produce images with low resolution:** *Resolution* is the ability to distinguish objects that are close together. Low-resolution images are fuzzy. High-resolution images are sharp. Generally, the larger the diameter of the telescope’s collecting surface, the higher the resolution of the image produced. And the shorter the wavelength of radiation used, the higher the resolution of the image that can be produced. Radio telescopes, despite their large diameter, produce very low resolution images because of the long wavelengths of radio waves. Infrared, on the other hand, has wavelengths closer to those of visible light.

Radiation Type	Passes Through Atmosphere?	Wavelength
Radio	Yes	> 1 mm
Infrared	Some	0.0007 mm–1 mm
Visible light	Yes	0.0004 mm–0.0007 mm
Ultraviolet	Small amount	0.00002 mm–0.0004 mm
X-ray	No	0.00000001 mm–0.00002 mm
Gamma	No	<0.0000001 mm

Answer the questions below on a separate sheet of paper.

1. Which form of radiation should give the highest resolution image? Why?
2. What do you suppose are the disadvantages of using a space telescope to make observations?
3. Suppose astronomers are interested in obtaining an image of a very large area in the sky that gives off equal amounts of radio waves, infrared waves, and visible light. Which radiation should astronomers observe if they want to get images 24 hours a day, quickly and cheaply? Why?
4. If astronomers want a very detailed image of an object behind a dust cloud, which radiation should they observe? Why?

## Design and Build a Telescope

### Problem

How can you design and build a telescope?

### Materials

2 paper towel tubes of slightly different diameters

several plastic objective lenses

several plastic eyepiece lenses

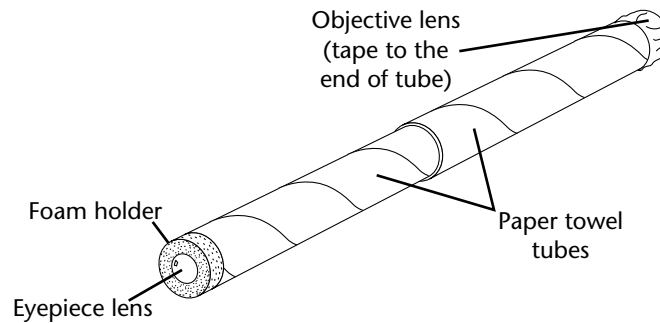
foam holder for eyepiece

transparent tape

meter stick

### Procedure

1. Fit one of the paper towel tubes inside the other. Make sure that you can move the tubes but that they will not slide on their own.



2. Place the large objective lens flat against the end of the outer tube. Tape the lens in place.
3. Insert the small eyepiece lens into the opening in the foam holder.
4. Place the foam eyepiece lens holder into the inner tube at the end of the telescope opposite to the objective lens.

**Stars, Galaxies, and the Universe** ▪ *Technology Lab*

5. Tape a meter stick to the wall. Look through the eyepiece at the meter stick from 5 m away. Slide the tubes in and out to focus your telescope so that you can clearly read the numbers on the meter stick. Draw your telescope. On the drawing, mark the tube position that allows you to read the numbers most clearly.
6. Use your telescope to look at other objects at different distances, both in your classroom and through the window. For each object you view, draw your telescope, marking the position at which you see the object most clearly. **CAUTION:** *Do not look at the sun. You will damage your eyes.*
7. Use what you learned to design and build a better telescope. Your new telescope should make objects appear larger than they appeared through your first model from the same observing distance. It should have markings on the inner tube to enable you to pre-focus the telescope for a given observing distance.
8. Draw a design for your new telescope. List the materials you'll need. Obtain your teacher's approval. Then build your new model.

**Analyze and Conclude**

Write your answers on a separate sheet of paper.

1. **Inferring** Why do you need two tubes?
2. **Observing** If you focus on a nearby object and then focus on something farther away, do you have to move the tubes together or apart?
3. **Evaluating the Design** How could you improve on the design of your new telescope? What effects would different lenses or tubes have on its performance?
4. **Redesigning** Describe the most important factors in redesigning your telescope.

**Communicate**

Write a product brochure for your new telescope. Be sure to describe in detail why your new telescope is better than the first telescope.