

Discover!

General Science 1

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Chapter 47

Tools of Astronomy

By the end of this chapter, you will be able to:

- identify some of the tools that astronomers use to observe and study the sky, such as telescopes, binoculars, cameras, and computers
- explain how different types of telescopes work and what they can reveal about the universe, such as optical, radio, infrared, X-ray, and gamma ray telescopes
- compare and contrast the advantages and disadvantages of ground-based and space-based telescopes
- demonstrate how to use a simple telescope or binoculars to observe the moon, planets, stars, and constellations

Chapter Review

If you need to review the electromagnetic spectrum, please go to the chapter titled “The Sun.”

Academic Vocabulary

Read the following vocabulary words and definitions. Look through the chapter. Can you find each vocabulary word? Underline the vocabulary word in your chapter and write the page number where you found each word on the blanks here.

- **binoculars:** a handheld optical instrument composed of two telescopes and a focusing device and usually having prisms to increase magnifying ability (p. ____)
- **gamma-ray telescope:** a scientific instrument designed to detect and observe gamma rays from celestial sources (p. ____)
- **infrared telescope:** a specialized astronomical instrument designed to detect and observe infrared radiation from celestial objects. Unlike optical telescopes, which primarily detect visible light, infrared telescopes are sensitive to the longer wavelengths of infrared light emitted by objects in space (p. ____)
- **optical telescope:** a type of telescope that collects and focuses visible light to observe and study celestial objects. It uses lenses or mirrors to gather and concentrate incoming light, allowing astronomers to magnify and analyze distant objects in the night sky (p. ____)
- **radio telescope:** a radio receiver-antenna combination used for observation in radio astronomy (p. ____)
- **telescope:** a usually tubular optical instrument for viewing distant objects by means of the refraction of light rays through a lens or the reflection of light rays by a concave mirror (p. ____)
- **X-ray telescope:** a specialized instrument designed to detect and observe X-ray radiation emitted by celestial objects in space. Unlike optical telescopes that primarily detect visible light, X-ray telescopes are specifically designed to capture and focus high-energy X-ray photons (p. ____)

Materials Needed

- concave mirror
- flat mirror
- magnifying glass or lens
(optional: 3 or 4 different magnifications)

THE BIG QUESTION

Do you think humans can see everything in the universe with the naked eye?

EXPLORE

The trip to the Everglades was amazing. You saw so many birds, alligators, and manatees, and the plants were incredible! Using binoculars, you were able to see the birds and alligators up close. **Binoculars** are a handheld optical instrument composed of two telescopes and a focusing device, and they usually have prisms to increase magnifying ability. When you get home, it is the first clear night in a week, so you decide to observe the stars with your star chart as soon as the sun sets. As you align your position to the chart, you notice a moving object in the sky.

"What is that?" you ask your uncle.

"That is a satellite orbiting Earth, probably the International Space Station. It's one of the few artificial satellites we can see with our eyes," Uncle Wally responds.

"Can we use the binoculars to help us get a closer view of the satellite and stars?" you ask.

"Yes, but a telescope is even better! I'll run in and get mine. Astronomers use **telescopes**, which are usually tubular optical instruments for viewing distant objects by means of the refraction of light rays through a lens or the reflection of light rays by a concave mirror."

While you wait, you wonder if there are objects in the night sky that are not visible to the naked eye.



Think about all of the celestial objects in the universe and name as many as you can. Why do you think astronomers and stargazers like to study space and see what is in the night sky? What types of tools do you think help them make observations?

CLOSER LOOK

Starlink Global Internet

Starlink is a satellite internet company that transmits internet data through radio waves to small satellites orbiting Earth, 300 miles above the surface. Ground stations broadcast signals to the satellites, which in turn relay the data back to Earth. Starlink has just over 4,000 working satellites and wants to put many more in orbit. Currently, Starlink provides internet for 56 countries; its goal is to provide high-speed internet all over the world, especially to remote areas.



Tools of Astronomers

Astronomers and stargazers have been looking at the night sky since the beginning of time. In ancient times, the skies were timekeepers. When certain stars appeared, humans knew to plant or harvest their crops. As civilizations developed, so did the advancement of tools to help navigate and observe celestial objects. In modern times, there are highly sophisticated satellites, telescopes, cameras, and computers to help observe the universe. Binoculars and telescopes can help magnify faraway objects. Cameras not only take images of the sky on Earth, but they are also on satellites to document images from space. Computers are another valuable tool that astronomers use to help store data, process data, and run simulations about space theories.

Celestial objects emit different types of electromagnetic waves. There are different types of telescopes designed to detect only a portion of the electromagnetic spectrum. The different types of electromagnetic radiation provide information about the universe, so it takes more than one kind of telescope to study all the objects in the solar system.



A time-lapse photo of the night sky focused on Polaris, the North Star.

WRITE

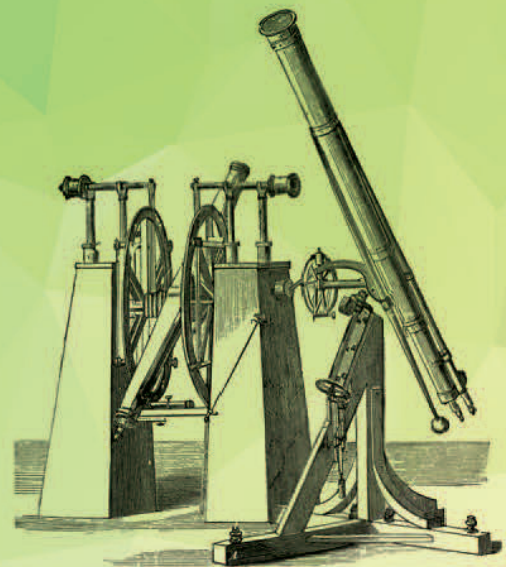
Short Answer

Think about the tools you use on a daily basis to help you learn and make life easier. Do you use any of the same tools that astronomers use? Do you use them in a similar or different way?

CLOSER LOOK

Telescope

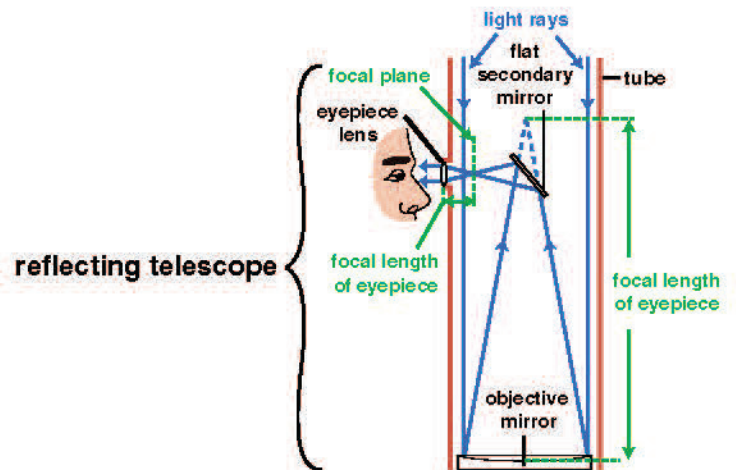
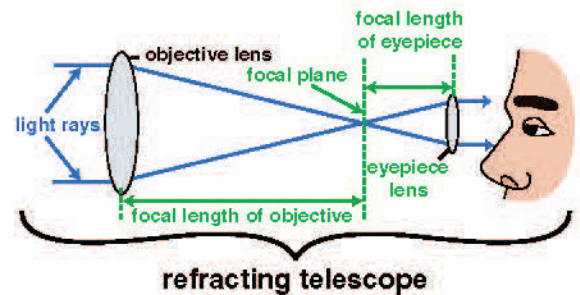
The word telescope is derived from the Greek word *tele* meaning far and *skopos* meaning seeing. In 1608, a Dutch eyeglass maker, Hans Lippershey, was the first person to patent a telescope. This device was called a *kijker*, or looker, and it was able to magnify an image up to three times its original size.



Ground-Based Telescopes

Uncle Wally explains how to focus the telescope as you look at the stars. As he does, he tells you more about telescopes. "There are two main types of telescopes: those that are ground-based and those that are space-based. X-rays, gamma rays, and some infrared light are blocked by Earth's atmosphere, so those types of telescopes must be space-based. Radio waves and visible light can pass through the atmosphere, so astronomers can observe those waves from Earth."

- **Optical Telescope:** collects and focuses visible light to observe and study celestial objects. It uses lenses or mirrors to gather and concentrate incoming light, allowing astronomers to magnify and analyze distant objects in the night sky. There are three types of optical telescopes: refracting (uses lenses), reflecting (uses mirrors), and refracting-reflecting (uses lenses and mirrors).
- **Radio Telescope:** a radio receiver-antenna combination used for observation in radio astronomy. Radio waves emitted from planets, stars, and galaxies tell astronomers about the composition, structure, and motion of these objects. Radio waves can be used at all times of day, and weather does not interfere with radio wave observations. The disadvantage is that high-powered computers are required to interpret the data returned by the radio waves.



WRITE

Short Answer

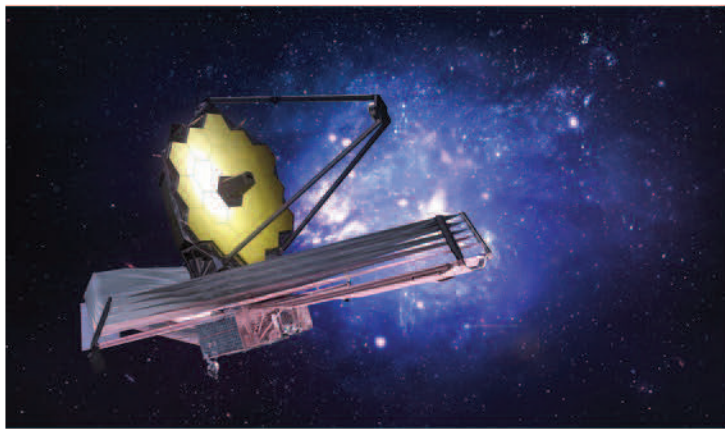
What are some advantages of a radio telescope over an optical telescope?

Spaced-Based Telescopes

Looking at the landscape of the moon is cool, but you start to wonder something. You ask, "Uncle Wally, how do astronomers see black holes and other things way beyond what this telescope can see?"

Uncle Wally is happy to tell you about space-based telescopes, like the James Webb Space Telescope, which uses infrared electromagnetic radiation to see the cosmos, and the older Hubble Space Telescope, which uses mirrors.

Space-based telescopes have clearer images, more access to objects in space, and can view a wider range of electromagnetic radiation and celestial objects. However, they are difficult to repair and maintain, and the technology is out of date.



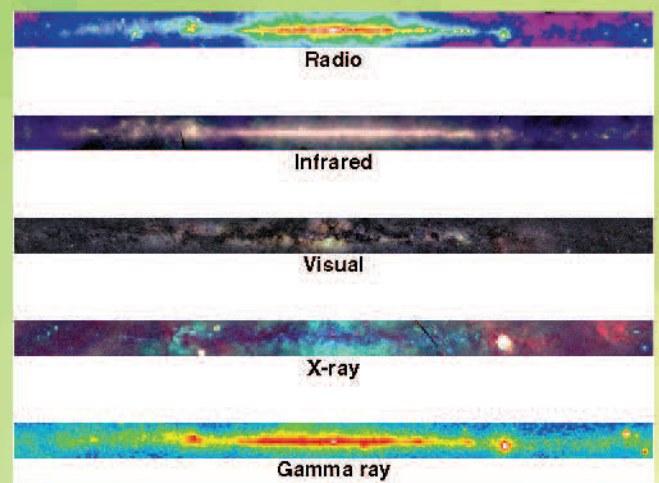
- **Infrared telescope:** a specialized astronomical instrument designed to detect and observe infrared radiation from celestial objects. Unlike optical telescopes, which primarily detect visible light, infrared telescopes are sensitive to the longer wavelengths of infrared light emitted by objects in space. These telescopes can tell you about the temperature of an object. Infrared telescopes let you look at cosmic clouds and dust to see inside them and behind them.
- **X-ray telescope:** a specialized instrument designed to detect and observe X-ray radiation emitted by celestial objects in space. Unlike optical telescopes that primarily detect visible light, X-ray telescopes are specifically designed to capture and focus high-energy X-ray photons. X-ray telescopes give information about the density, temperature, and composition of celestial objects and environments.

- **Gamma-ray telescope:** a scientific instrument designed to detect and observe gamma rays from celestial sources. Gamma waves are produced by exploding stars, black holes, and colliding celestial objects. They can provide clues to the shape and size of the universe.

CLOSER LOOK

Electromagnetic Radiation Images

These photos from NASA show the Milky Way galaxy under the different types of telescopes. Note that the radio and gamma images are similar, but they highlight different details.



"Multiwavelength Milky Way Images" from NASA.

How to Use a Telescope

As you finish up your observations of the moon, your parent comes out and asks what is going on. You have been out for two hours using Uncle Wally's telescope, and it's way past your bedtime!

"I saw craters on the moon," you respond. "It was so beautiful. Do you want to try it?"

"I have never looked in a telescope before. Can you help me figure it out?" they say.

"Just follow these steps:

"Step 1: Make sure the telescope is away from bright lights and obstructions like that tree over there. As you can see, we have already placed the telescope on a tripod.

"Step 2: Align the telescope to an object. Point the telescope toward a distant, easily identifiable object. Adjust the telescope's position until the object is in the center of the field of view.

"Step 3: Focus the telescope. While looking through the eyepiece, slowly turn the focus knob until the object you are observing is clear and in focus. Once you have done this, you can start to look at objects in the sky."

Consider these helpful hints when observing celestial objects.

Start with the moon: The moon is a great celestial object to begin with. Aim the telescope at the moon and observe its craters and features.

Observe other planets: Identify bright objects in the night sky, like Venus, Mars, or Jupiter. Look for their distinctive colors and features.

Observe stars and constellations: Point the telescope toward stars or clusters and observe their brightness and patterns.

Most importantly, be patient; sometimes it takes time to find and focus on an object.



MINI-LAB

Build your own reflecting telescope!

Materials: flat mirror, small concave mirror, magnifying glass or lens (optional: 3 or 4 different magnifications)

Directions:

1. Position the concave mirror so you can see the reflection of the object in it. It is best to do this at night when the moon or stars are visible.

Warning: Never observe the sun directly or with mirrors.

2. Place the flat mirror so it is facing the concave mirror and adjust it until you can see the reflection of the object in the flat mirror.
3. View the image in the flat mirror with your magnifying glass. Use different magnifying lenses to view the image.

Questions:

1. What happens when you move the magnifying glass toward or away from the mirror?
2. Describe how the image changed when you used different magnifying lenses.
3. Record any other observations.

Pull out your General Science 1 Lab Book and record your answers and reflections in the space provided for the Chapter 47 Mini-Lab or make the appropriate notes in a regular notebook and share with your instructor.

PRACTICE

Astronomy Tools

Complete the chart for each type of telescope.

	Ground- or Space-Based	What does it observe?	Advantages	Disadvantages
Binoculars				
Optical				
Radio				
Infrared				
X-ray				
Gamma				

REVIEW

In this chapter, you learned:

- Astronomers use telescopes to observe and study the sky.
- Different types of telescopes provide different images.
- There are advantages and disadvantages of ground-based and space-based telescopes.
- You can use a simple telescope to observe the moon, planets, stars, and constellations.

Can you answer The Big Question?

The universe consists of many different celestial objects. There are planets, comets, asteroids, meteoroids, stars, red giant stars, galaxies, moons, nebulae, black holes, and more. These objects all emit different types of electromagnetic waves. Do you think humans can see everything in the universe with the naked eye?

SHOW WHAT YOU KNOW

Choose the correct answer for each question.

1. A handheld optical instrument composed of two telescopes, a focusing device, and usually having prisms to increase magnifying ability is called _____.
A. a telescope
B. a gamma telescope
C. binoculars
D. a camera
2. A _____ telescope is a type of telescope that collects and focuses visible light using concave mirrors to bend the light to observe and study celestial objects.
A. reflecting
B. refracting
C. radio
D. infrared
3. Which one is NOT an advantage of ground-based telescopes versus space-based telescopes?
A. cheaper to make
B. clearer images
C. up-to-date technology
D. easy to repair
4. Earth's _____ blocks certain types of electromagnetic radiation from celestial objects.
A. crust
B. orbit
C. moon
D. atmosphere

Read each sentence. Circle True or False.

5. True or False The James Webb Telescope is a satellite in space.
6. True or False Earth's atmosphere scatters radio waves, so all radio telescopes are moon-based.
7. True or False You can use binoculars to see the moon better than with the naked eye.
8. True or False It is easy to see satellites in orbit.

Answer the following question.

9. Compare and contrast the two types of ground-based telescopes.

IN FOCUS

Imagine you are an astronomer designing the next space telescope. Design a prototype and describe what information you will be collecting. Make sure to include the technology and tools that are on the satellite and what they will be collecting.



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