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## Vocabulary Words

**distort** (di stōrt'): to change or twist something out of its normal condition

**element**: matter that is made up of one type of atom

**eyepiece**: the lenses nearest the viewer's eye in a telescope or microscope

**spectrum** (spek' trəm): the colors of the rainbow that are produced by shining white light through a prism

△ **Pronounce these words to someone.**

The science of astronomy has taught us much about our universe and the heavenly bodies in it. A number of tools have been invented that help man discover the secrets of the beautiful dark dome above him. The telescope is the astronomer's most important tool for observing stars and other heavenly bodies. The telescope has provided a window into the heavens that ancient astronomers missed out on. This window into the heavens should make us ever more aware of God's unlimited power in creation.

### Telescopes

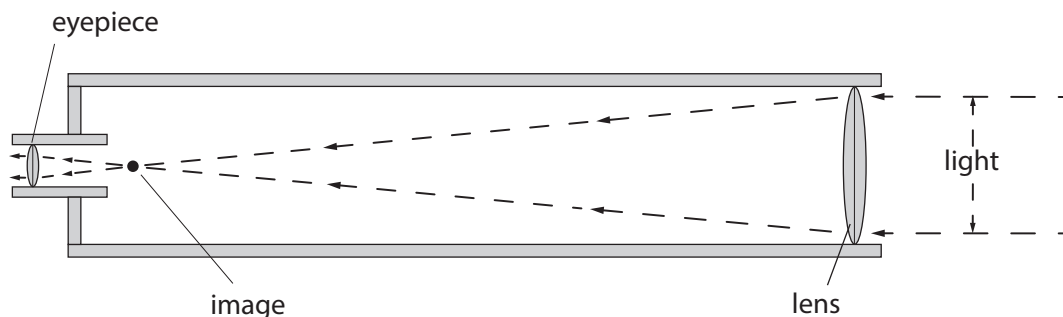
Have you ever looked at the stars through a pair of binoculars? They likely served as a much better telescope than Galileo had. Galileo's telescope was a simple refracting telescope. A refracting telescope is made of a number of lenses that gather and focus light.

The largest refracting telescope is at Yerkes Observatory in Wisconsin. The lens of this telescope is 40 inches in diameter and weighs 760 pounds!

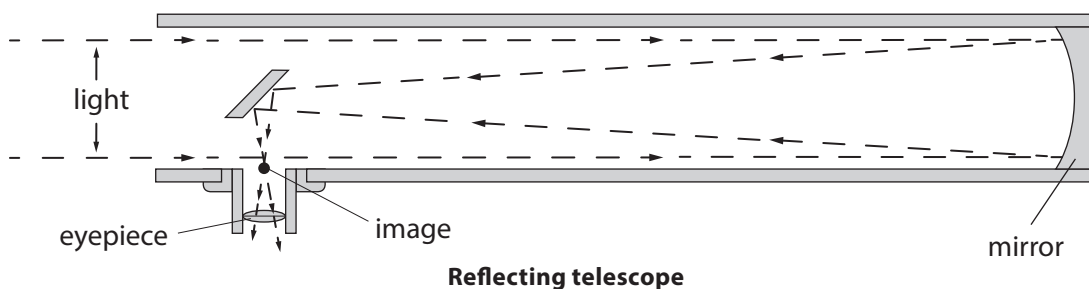
Another type of telescope is the Newtonian reflecting telescope, named after Newton who designed and built the first one. A curved mirror reflects an image onto a smaller mirror. This small mirror is mounted at an angle and reflects the image out a hole in the side of the telescope. An **eyepiece** mounted on the hole magnifies the image.



The Gran Telescopio Canarias in the Canary Islands



Refracting telescope



Reflecting telescope

In 2015 the world's largest reflecting telescope was the Gran Telescopio Canarias (Canaries Great Telescope) in the Canary Islands off the coast of West Africa. This telescope has a mirror with a diameter of 10.4 meters (34 ft)!

As you study these diagrams of the two types of telescopes you will notice some of their differences. A refracting telescope uses a lens to focus light, but a Newtonian reflecting telescope uses a mirror to focus light. On a refracting telescope the eyepiece is at the bottom end of the tube, but on a reflecting telescope the eyepiece is on the side of the tube.

### Cameras

Astronomers also use cameras for exploring the sky. They take pictures of the stars that can be kept, compared, and studied later. An advantage of photographing stars is that the camera is more sensitive to light than the eye. In other words, a camera can “see” better than the human eye. It is another marvelous window into the heavens.

The first sun photos were taken in 1845 and the first moon photos were taken in 1850.

### The Spectroscope

The spectroscope is an important tool for astronomers. Two main uses are to determine the composition of the sun and other stars, and to measure the movement of stars.

The white light we see is really composed of all the colors of the rainbow: red, orange, yellow, green, blue, indigo, and violet. This is called the **spectrum**. The spectroscope separates white light into the colors of a spectrum.

Stars are composed of several different **elements** and each element creates its own light pattern. This can help astronomers determine what elements are in the stars. For example, light given off by hydrogen makes a certain pattern of color when it is measured by the spectroscope. If that specific pattern appears in the light from a star, astronomers know hydrogen occurs in that star.

When stars move away from or toward the earth the patterns of light given off by the elements of the star are changed. By carefully measuring these changes, astronomers can determine whether a star is moving toward or away from the earth. Astronomers can also look at these changes to measure the speed of a star.

### Radio Telescope

In 1931, Karl Jansky discovered radio waves were coming to the earth from space. He built a radio receiver to pick up these waves from stars, clouds of gas, and dust in outer space.

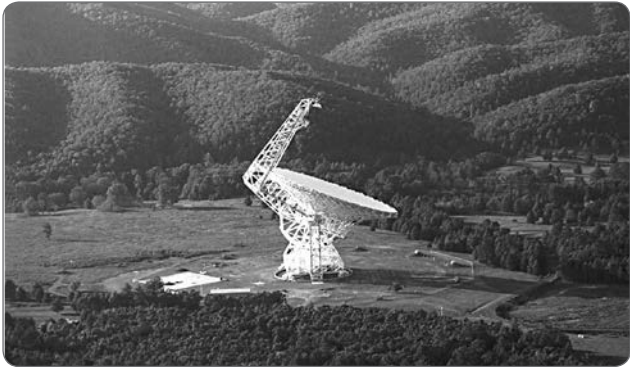
The radio telescope has become an important tool in astronomy. It consists of two parts—an antenna and a radio receiver. The antenna is focused toward a particular region of the sky. Radio waves are collected and reflected by the bowl-shaped antenna to a small receiver at the center of the telescope. The receiver changes the radio waves into electrical signals and passes them to a recording instrument where the data is graphed.

Currently the world's largest radio telescope is the FAST (Five hundred meter Aperture Spherical Telescope) in China. As the name suggests, its antenna is 500 meters (1,600 ft) in diameter.

Though the heavens appear to be silent, we now know there is noise (energy) out there. In Job 38:7,

## Lesson 14

God asks Job where he was “when the morning stars sang together.” Do you suppose Job was as surprised as men today when they learned about the “music” of the stars?



The Green Bank Telescope (GBT) is the largest fully-steerable radio telescope in the world.

### Space Telescopes

Have you ever noticed that stars “twinkle”? This is caused by air currents in the atmosphere **distorting** the light traveling to your eyes. This is a problem for telescopes on the ground because it makes their pictures blurry. To solve this problem, scientists launched the Hubble Space Telescope in 1990. Hubble can take much clearer pictures than ground-based telescopes because it does not have to deal with the blurring effects of the atmosphere.



Hubble Space Telescope

Space telescopes are also useful because Earth’s atmosphere blocks some types of light such as ultraviolet (UV), X-rays, and gamma rays. Although it is good these harmful rays can’t make it to Earth’s surface, it also prevents astronomers from using telescopes that can see these types of light. Above the atmosphere, space telescopes can take pictures and send them to astronomers on Earth.

Space telescopes have been used to take magnificent pictures of stars and galaxies. When you look at these spectacular images, you can’t help but praise our powerful Creator of a beautiful universe.



The Hubble telescope took this picture of the Sombrero Galaxy.

## Study Exercises



### Answer the questions.

1. What is the astronomer's most important tool? \_\_\_\_\_
2. What are all the colors of the rainbow called? \_\_\_\_\_
3. Why do stars appear to twinkle? \_\_\_\_\_  
\_\_\_\_\_



### Circle the letters of the answers.

4. What two things about stars do spectroscopes measure?
  - a. position
  - b. movement
  - c. temperature
  - d. composition
5. Which two statements are true about the parts of a radio telescope?
  - a. The eye piece sends images to a lens.
  - b. The mirrors and the antenna work together.
  - c. The antenna collects and reflects radio waves.
  - d. The radio receiver changes signals and sends them on for recording.



### Match the instruments with their descriptions. Some instruments will be used more than once.

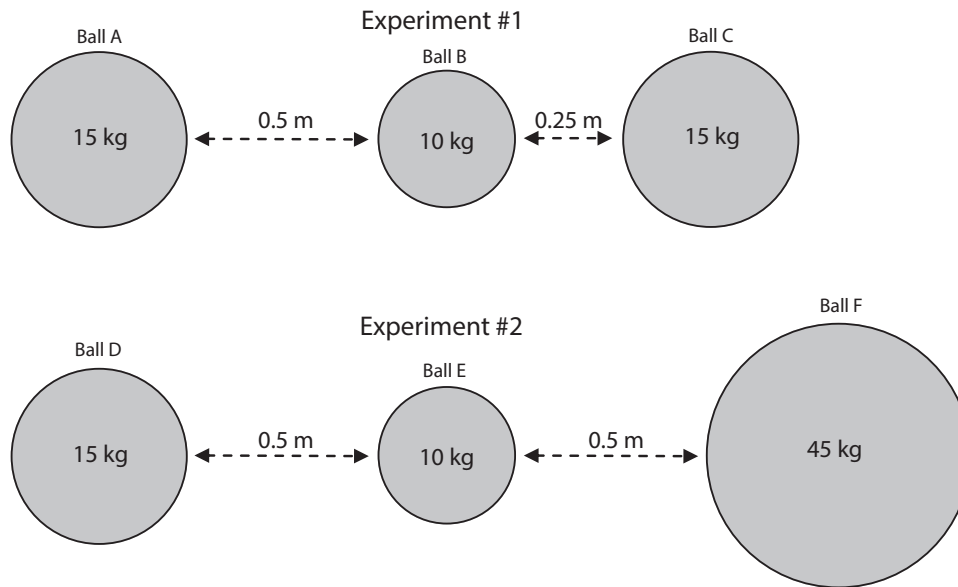
6. \_\_\_\_\_ telescope with eyepiece on the side
7. \_\_\_\_\_ telescope with eyepiece on the end
8. \_\_\_\_\_ separates white light into colors
9. \_\_\_\_\_ uses lenses to focus light
10. \_\_\_\_\_ uses mirrors to focus light
11. \_\_\_\_\_ uses an antenna to collect waves
12. \_\_\_\_\_ more sensitive to light than human eyes
13. \_\_\_\_\_ takes clearer pictures than ground-based telescopes

- a. camera
- b. radio telescope
- c. reflecting telescope
- d. refracting telescope
- e. space telescope
- f. spectroscope

## Lesson 14



Answer the questions using the Laws of Gravity on page 44 and the diagrams below. To test Newton's Laws of Gravity a group of scientists set up two experiments using iron balls of different masses placed at different distances. Diagrams of the experiments are shown below.



Circle the letter of the answer.

*In Experiment #1, the scientists discovered there was more gravitational force between Balls B and C than between Balls A and B.*

14. Which two balls are placed closest together?
  - a. A and B
  - b. A and C
  - c. B and C
15. Why did the scientists get the results they did?
  - a. Ball C has a greater mass than Ball B.
  - b. Ball A and C have the same mass, but Ball C is closer to Ball B.
  - c. Ball A and C have the same mass, but Ball A is closer to Ball B.
  - d. Balls A and C have a greater mass than Ball B.
16. Which of the Laws of Gravity describes what caused this result?
  - a. First Law
  - b. Second Law
  - c. Third Law

*The scientists then performed Experiment #2. Predict the results of the experiment using the Laws of Gravity.*

17. Which of the balls is largest?
  - a. Ball D
  - b. Ball E
  - c. Ball F

18. Between which two balls is there the most force?
- a. D and E  
b. E and F  
c. D and F
19. Which of the following statements best describes why you gave the answer you did?
- a. The balls are the same distance apart, but the mass of Ball D is greater than Ball E.  
b. Ball D is closer to Ball E, and Ball D has a greater mass than Ball E.  
c. Ball F is closer to Ball E, and Ball F has a greater mass than Ball D.  
d. The balls are the same distance apart, but the mass of Ball F is greater than Ball D.
20. Which of the Laws of Gravity explains what you predicted?
- a. First Law  
b. Second Law  
c. Third Law

## Looking Back



Write *true* if the statement is *true* and *false* if it is *false*. Correct any false statements.

21. \_\_\_\_\_ The Laws of Gravity were developed by *Kepler*.
22. \_\_\_\_\_ The force of *motion* holds the universe together.
23. \_\_\_\_\_ A planet with less mass than earth will have *lower* gravity.
24. \_\_\_\_\_ Newton built a *refracting* telescope that he used to view the heavens.
25. \_\_\_\_\_ Every object in the universe exerts a *gravitational pull* on every other object.
26. \_\_\_\_\_ The closer two objects are, the *greater* the gravitational force between them.
27. \_\_\_\_\_ Galileo and Newton's *experimental* method was new for scientists of that time.

## Research

## Astronomer's Tools

Follow these directions.

Choose one of the astronomer's tools and do further research on it. Then share what you learned in a 200-word report. Remember to tell everything in your own words. Give your report to your teacher or share it with your class as your teacher directs.

## Did You Know?

- ▶ Many ground-based telescopes are placed on top of mountains so they are above much of the atmosphere.
- ▶ Hubble is not the only space telescope. There are also telescopes that take pictures of stars and galaxies using types of light that human eyes cannot even see.