

History and Discovery of Asteroids

Seeing Faraway Things as Though Nearby

FLASHBACK—Astronomy with the First Telescopes

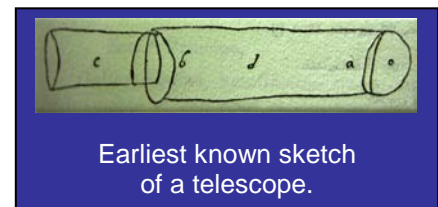
The work of early scientists like Copernicus¹, Brahe, and Kepler² was remarkable since all their observations of the night sky were made by simply using their own eyes. The invention of the telescope, a technological breakthrough, allowed scientists to “extend their senses” for the first time. Therefore, it is considered one of the central instruments in what has been called the Scientific Revolution of the 17th century.

Who Invented the Telescope?

No one knows for sure who invented the telescope. It may have been two little children who were playing with lenses in the shop of **Hans Lippershey**, a Dutch reading-glasses maker. The story is told that when the children looked at a weather vane on a nearby church through two lenses held together, it became larger and clearer. The rest of the story is that Lippershey then put a tube in between the two lenses, thereby inventing one of the first telescopes. This early model only magnified an image by three or four times. This means that a marble seen through this device would appear three or four times larger than its actual size—maybe the size of a ping-pong ball.



Lippershey was the first person to try to sell his telescope. In 1608, he applied to the Belgian government for a **patent** on a device with multiple lenses. A patent would protect his idea from being stolen by another person. Lippershey was required to make three identical telescopes and to keep his method a secret. Making more devices was not a problem for him, but he had trouble keeping his secret. So, a short time later, **Jacob Metius** applied to the same government office for a patent on a device for “seeing faraway things as though nearby.” His device was a tube with one convex lens (curved outward) and one concave lens that curved inward.



Earliest known sketch of a telescope.

There are two different versions of what the government’s patent board decided. One version is that they turned down Metius’ application. Metius became so upset that he refused to show his telescope to anyone. It is said that even the tools he used to make it were destroyed after he died. The other version of the story says that government officials discussed the patent applications of both Lippershey and Metius. They thought that the device was too easy to copy to patent, so they gave Metius a small amount of money and paid Lippershey “handsomely” to make several copies of his device.

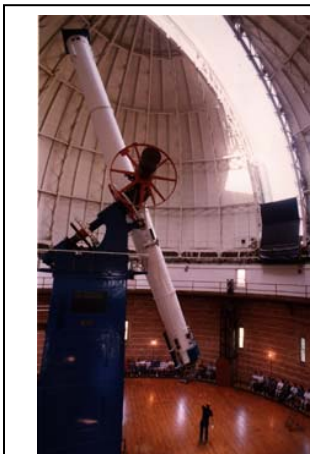
These early devices looked more like our modern day “spyglasses” than our modern telescopes. Because they used lenses that **refracted** (or bent) light, they were called **refractor** telescopes.

Galileo Received Undo Credit for the Refractor Telescope

In July of 1609, **Galileo Galilei** heard that Lippershey was on his way to Venice to sell his invention “that made distant objects seem near.” Galileo needed money, and the Venetians were offering Lippershey a high price for his device. In 24 hours, Galileo had a telescope made and sent word of “his invention” to a monk in a high office of the government. For this, Galileo received a raise in salary from 520 to 1000 florins per year.

Whatever the truth of these stories, three things are certain. One, the first telescopes were not invented by scientists, but by craftsman; two, Galileo did not invent the refractor telescope; and finally, telescopes revolutionized astronomical observation. Scientists depended upon larger and better telescopes to advance their study of the universe.

Astronomers used the new telescope to make better observations.



The 40-inch refractor at the Yerkes Observatory set out to be the largest telescope in the world when construction began in 1890. Today, it still is the largest, measuring over 60 feet (19 meters) and weighing 20 tons. A special dome and floor had to be custom built for the telescope.

Galileo used refractor telescopes with lenses that magnified objects about 20 times their size. With these instruments, he discovered the moons of Jupiter, the rings of Saturn, the changing apparent shape of Venus, sunspots, and solar rotation in less than ten years. Not only were such discoveries groundbreaking, they were extremely controversial in those days because they called into question the widely accepted **geocentric** belief that Earth was the center of the universe. Instead, Galileo's findings pointed to the controversial **heliocentric** theory; all planets rotated around the sun, not the Earth. During the same decade, at least ten other astronomers built their own refractor telescopes using different combinations and types of lenses. Many of these were used to verify, support, and extend Galileo's discoveries.

Early Refractor Telescopes Reached Their Limits

There were several drawbacks to Galileo's telescopes. They only allowed for a narrow field of view, and the images produced through the lenses were blurry. Around 1630, a German astronomer, **Johannes Kepler**, proposed some solutions. To widen the area that could be visible through a telescope, Kepler suggested the concave eyepiece be replaced by a convex one. This design initially produced an upside-down image, which was later corrected by the two-convex lens design. Kepler also discovered that by flattening the shape of the lens, the image quality could be improved. This solution, however, presented a new challenge. With a flatter lens, the only way to increase the magnification power of the early refractors was to increase the length of these telescopes.

While Galileo's discoveries were made with telescopes of five or six feet (1 ½ meters), by the middle of the 17th century, the length of refractor telescopes quadrupled. To achieve further discoveries, telescope designs became longer and longer and eventually were too large to control.

Isaac Newton Built a Reflector Telescope

Another design flaw of the early refractor telescope was that the glass lenses caused light to separate into colors. You may have observed how a glass prism creates a rainbow effect; similarly, the early refractor telescope lenses produced a distracting ring of color around bright objects, referred to as **chromatic aberration**. An English scientist, **Sir Isaac Newton**, found a way around this by using metal mirrors instead of glass lenses to help focus the light rays. Not only did this design remove the color, or chromatic aberration, Newton's **reflector** telescope, built in 1668, was only about six inches long and able to magnify objects 40 times.

Some of the best reflector telescopes were designed and constructed by **William Herschel**, a musician turned observational astronomer. He built a telescope that was used by **Johann Schröter**, the elected president of a society sometimes called the **Celestial Police**³. This group was formed for the expressed purpose of searching for and discovering the "missing planet" that Kepler² predicted would be found between the orbits of Mars and Jupiter.

As with the early refractor telescopes, images continued to be blurry with the early reflector telescopes until technology made it possible to grind the lenses and mirrors into different shapes. Moreover, Newton's design led to a new problem as the metal mirror tarnished easily and required frequent polishing. Nevertheless, the introduction of a new type of telescope sparked a new surge of astronomical discoveries. And likewise, scientific

pursuits continued to inspire improvements to existing telescope technology. Today, all modern research telescopes and large amateur ones are of the reflector type.

¹ see “Thinking Outside the Box” flashback

² see “Between Jupiter and Mars” flashback

³ see The Activity “In Search Of...” The activity shows how the Celestial Police carried out their investigations.

Additional Resources

<http://amazing-space.stsci.edu/resources/explorations/groundup/>

Telescopes from the Ground Up presents an informative and interactive history of telescopes from Galileo’s era to today’s NASA observatories. The site also offers helpful explanations of the basic science concepts behind telescope technology, some of which include interactive features to illustrate the concepts.

<http://astro.uchicago.edu/vtour/>

Take a virtual tour of the 100-year old Yerkes Observatory at the University of Chicago. See and learn about the five research telescopes used at the observatory, including the largest refractor telescope.

<http://brunelleschi.imss.fi.it/museum/esim.asp?c=500033>

This site features images and descriptions of telescopes from the 17th, 18th, and 19th centuries, including those used by Galileo. Furthermore, the site offers a short video about the invention of the telescope.

<http://galileo.rice.edu/index.html>

The Galileo Project presents information on the life and work of Galileo as well as the science of his time.

<http://hou.lbl.gov/~vhoette/Explorations/OpticalPowers/1-telescope-pictures.html>

This site provides many pictures of the telescopes available at The University of Chicago Yerkes Observatory. Also a question activity is included to get learners to figure out the different parts required for different kinds of telescopes.

http://www.childrensmuseum.org/cosmicquest/fieldguide/astro_renaissance.html

This site presents brief biographies of Galileo and other Renaissance astronomers.

<http://www-gap.dcs.st-and.ac.uk/~history/Mathematicians/Galileo.html>

This site has more information about Galileo, his family, and his work.

Guiding Questions

1. Prior to the invention of the telescope, how did early scientists (e.g., Copernicus, Brahe, and Kepler) make observations of celestial bodies?
2. In technology development, many people are usually involved over a period of time. Often, however, one person gets credit.

- a. What are some of the conflicting stories regarding the individuals who were involved in the invention of the first telescopes? Provide details: Who? What? and Where?
 - b. During what time period was the telescope invented?
 - c. Who received credit for the invention?
3. How did science advance as a result of the invention of the telescope?
- a. What were some of the discoveries made using early telescopes?
 - b. Who was responsible for these discoveries?
4. Science and technology depend on each other to progress. The need for better science drives improvements in technology, and vice versa, technological improvements make scientific advances possible.
- a. What were some of the improvements that were made to the early refractor telescopes?
 - b. What is the difference between the refractor and the reflector?
 - c. Why was the reflector telescope built? How was it an improvement over the refractor telescope?
 - d. Who was one of the first to build this type of telescope? When was it built?
5. How did the telescope, and the contributions of those who used the early telescopes, revolutionize astronomical observation?