The Glory of the Stars

CHAPTER 3

3A Tools for Studying the Stars

3.1 Introduction

On a clear night the unaided eye can see thousands of stars. The telescope seems the obvious tool to use to study astronomy. However, many other instruments have been used by both ancient and modern astronomers. With the variety of tools available, astronomers can record and measure a star's position, distance, movement, composition, size, shape, color, brightness, and temperature.

3.2 Constellations

History does not identify the people who first studied the stars and grouped them into patterns called **constellations**. Soon after Creation men must have realized the need to study the heavens. There are references in some ancient documents to even older lost writings, indicating that the constellations were likely known before the Flood. Following the Flood, constellations are mentioned in the book of Job (38:31–32), which records events in the life of a man who probably lived before Abraham. The Greeks were familiar with similar constellations. Homer's *Odyssey*, written about 800 BC, mentions that Ulysses navigated his ship homeward by observing constellations. He gazed "with fixed eye on the Pleiades, on Bootes setting late, and on the Larger Bear." Apparently the constellations were common knowledge to ancient peoples. Knowledge of the heavens was necessary in order to guide travelers and to keep accurate calendars.

constellation: con- (L. *com*—together) + -stellation (L. *stella*—star)

3.3 The Gnomon

Ancient astronomers developed several devices to help them determine the position and motion of the heavenly bodies. One of these old devices, the **gnomon**, cast shadows in sunlight. The gnomon was an upright stick or pole, a column of stones, a pyramid, or a tall stone pillar. Astronomers used the daily movement of the gnomon's shadow to estimate the time of day and the changes in the length of the shadow to estimate the time of year. While not used directly to study the stars, the instrument served as a crude clock and calendar and gave astronomers an ability to judge the motion of the sun and stars. Later astronomers added a numbered dial to the gnomon to make a sundial.

3-1 This armillary, located outside the National Solar Observatory, contains a sundial.

gnomon (NOH mun)

3.4 Instruments

Astronomers used many instruments that helped them locate the stars or the sun by sighting along fixed points. Early sighting "instruments" included natural features such as mountain peaks as well as stones or buildings set up to align with a star or the sun at a particular time of year. The earliest observatories often were set up to view the sun at the beginning instant of summer or winter (at the summer or winter solstice). Stonehenge, a ring of stones in England, is apparently an early observatory for determining celestial

3-2 Stonehenge may have been erected as a solar observatory.

quadrant (KWAHD rent): An instrument for measuring the altitude of celestial bodies that consists of a 90-degree arc with a movable sighting arm. Sextants contain a 60-degree arc; octants a 45-degree arc.

3-3 Octants were used to read the angle a star made with the horizon.

3-5 At his palatial observatory on the Isle of Hven, Tycho and his assistants used the most up-to-date instruments to record remarkably precise observations of the positions of stars and planets.

events such as solstices and equinoxes. Later instruments incl scales to measure a star's position. The **quadrant**, sextant, and oc were handheld instruments having a movable index arm that i cated the angle of elevation between a star, the sun or moon, and horizon.

Clocks were also important to ancient astronomers. Most peo used the sun to measure time, but astronomers wanted to time sun's motion, which required a method separate from the sun. first clocks that did not rely on the sun included water clocks sand clocks (hourglasses). These measured time by how long a c tain amount of water or sand flowed through a hole. Burning can could be used as crude timers as well. Candles of uniform size m ured time by how long it took to burn a marked length of the can These clocks were inaccurate because the water and sand did flow at a constant rate, and the candles did not burn uniformly. N ertheless, these clocks gave ancient astronomers some idea of stars' and planets' rates of motion.

Ptolemy, a Greek astronomer of the second century AD, reco the observations of astronomers who used such equipment. His t teen-volume work, called the *Almagest*, included a two-volume catalog of the stars. This was the main reference work for almost fifteen hundred years and was used by such great astronomers as Nicolaus Copernicus and Tycho Brahe. Tycho was probably the best pre-telescope observer. He equipped his observatory, *Uraniborg*, with instruments to plot the positions and movements of the sun, moon, comets, and planets. These instruments and his powers of observation together produced very accurate observations. Tycho died in 1601, eight years before Galileo pointed his first telescope toward the heavens.

3-4 Water clocks were amo the first clocks that did not rely on the sun.

3A-1 Section Review

1. When is it probable that people first studied stars and groupe them into constellations?
2. What two benefits did knowledge of the heavens give to early civilizations?
3. What name was given to an early device that was used to ind cate time and seasons by the shadow it cast in sunlight?
4. What was the above instrument called when a numbered dial was added?
5. What early work used by Copernicus and Tycho contained a ca alog of stars? Who was the author?
6. (True or False) Ancient astronomers could accurately time the sun's motion with a sundial.

3.5 Refracting Telescopes

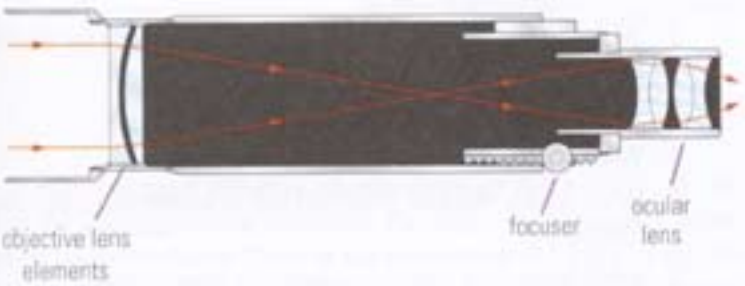
Roger Bacon was one of the first to investigate the use of lenses. By the 1300s, spectacles were available in Italy. The first telescopes began to appear in Holland in 1608, probably as a result of the work of Hans Lipperhey. He discovered that two lenses, when placed an appropriate distance apart, made objects appear to be much closer. He envisioned the telescope as a military aid, but not for astronomical use.

Roger Bacon (1220–92) was an English philosopher, scientist, and professor at Oxford University. He pioneered studies in several fields, including optics.

Hans Lipperhey (1570?–1619?) was a Dutch spectacle maker credited with inventing the telescope.

3-6 Galileo demonstrates one of his telescopes. The 136 cm long telescope (right) built by Galileo can magnify 20 ×.

Galileo Galilei was the first astronomer to build a telescope for viewing the heavens. His telescope consisted of two lenses, one mounted at each end of a tube that could be adjusted in length to focus the image. It was a **refractor telescope** because it used only lenses to magnify an image. The lenses on the refractor telescope bend light from a star or planet to make it appear larger and closer. The first lens **refracts** the light from the planet to concentrate the light as a small image, and the second lens refracts the light to magnify that image. Thus, the refractor telescope is a combination of an **objective** (light-gathering) **lens** and an *eyepiece* or **ocular** (magnifying) lens. Astronomers use the diameter of the refractor's objective lens to indicate its size. The largest refractor telescope in the world is the 102 cm (40 in.) telescope at the Yerkes Observatory in Williams Bay, Wisconsin.



3-8 A refractor telescope uses an objective lens to gather light and an ocular to magnify the image produced by the objective lens.

refract: re- (L. *re*—again) + -fract (L. *frangere*—to bend or break) Refraction occurs when a wave moves from one substance into another, changing the speed and direction of the wave.

3-7 The world's largest refractor, with a 40 in. objective, is located at Yerkes Observatory in Williams Bay, Wisconsin. Because of the weight of the objective lens, a refracting telescope larger than this would not be practical.