

## Tycho Brahe

Undoubtedly Danish astronomer **Tycho Brahe** (December 14, 1546 –October 24, 1601) was the greatest astronomical observer of the pre-telescopic era. He made a remarkable star catalogue of over 1000 stars, far more than any astronomer before him. If he is less honored than his assistant Johannes Kepler, it is because he rejected the Copernican heliocentric theory. While no one could actually *feel* either the rotation or the revolution of the Earth, it was possible to *see* the apparent movement of the Sun. Besides a rotating and revolving Earth did not fit in with Aristotle's generally accepted physical theory of motion. To Tycho, these arguments were conclusive proof that the Earth was stationary. Yet Tycho Brahe's



contribution to astronomy is enormous. He profoundly changed astronomical observational practices. Earlier astronomers were content to observe the positions of the planets and the Moon at certain important points in their orbits. Tycho and his assistants observed these bodies throughout their orbits. His observations of planetary positions were made using instruments with open sights, as telescopes were not used in astronomy until about 1609. He compiled extensive data on the planet Mars, allowing Kepler to deduce his three laws of planetary motion and to demonstrate that the orbit of Mars was not a circle but an ellipse. When Kepler set out to construct the orbit of Mars, assuming that planetary orbits were perfectly circular, no matter how hard he tried he couldn't make Tycho's observations fit a circular path. When he replaced the circle with an ellipse, the observations matched perfectly.



Tycho Brahe was born at Knudstrup in Skane (now a part of Sweden), the eldest son and surviving member of a pair of twin boys of Otte Brahe and his wife Beate Billie, both members of influential noble Danish families. Tycho was raised by his paternal uncle, Jørgen Brahe, a country squire and war admiral. Jørgen, who was childless, convinced his brother to allow him to adopt Tycho but Otte, reneged on the promise. When Beate gave birth to a second son, Jørgen abducted Tycho. The bad blood caused by this "kidnapping" cooled with the realization that Tycho would be in line

for a huge inheritance from Jørgen. The latter envisioned Tycho as a lawyer and insisted he begin the study of Latin when he was seven. In preparation for a legal career Tycho studied Rhetoric and Philosophy at the University of Copenhagen. But on

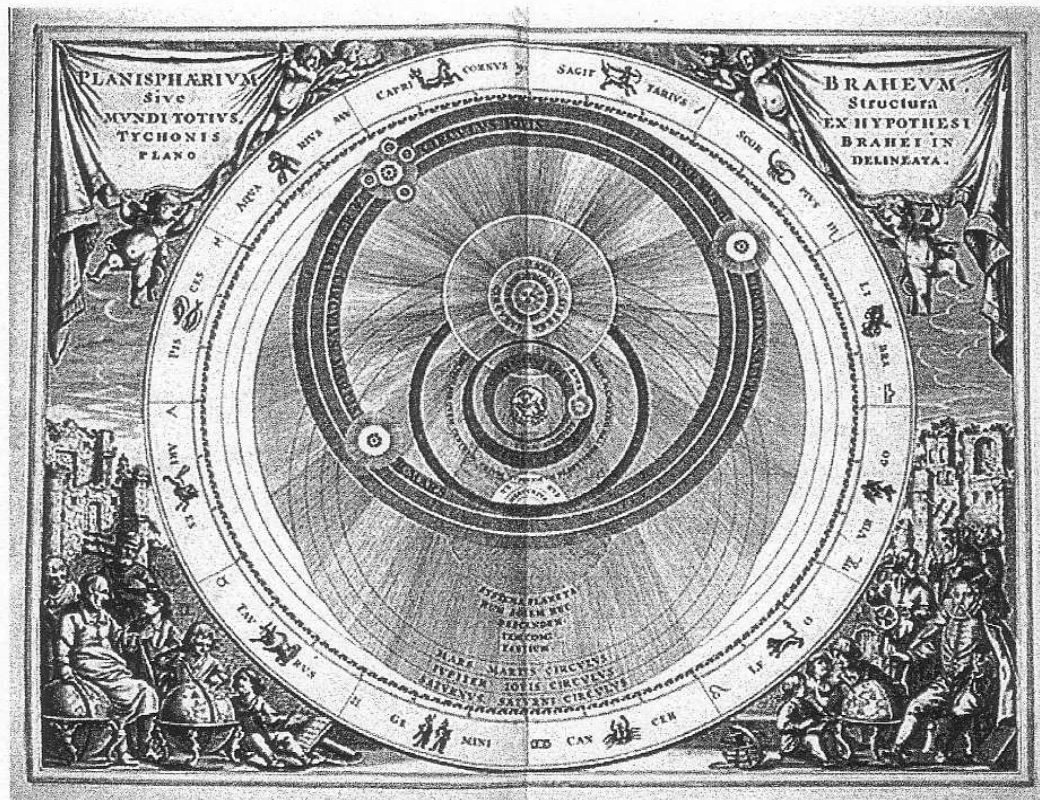
August 21, 1560, 14-year-old Tycho witnessed the partial solar eclipse and from that moment decided to devote his life to the study of astronomy. He was sent to Leipzig in Germany to continue his study of the law accompanied by a twenty-year-old tutor, Anders Vedel, later to become Denmark's first great historian. Tycho had no intention of abandoning his dream. He acquired a Latin copy of Ptolemy's *Almagest*, as well as sets of the Alfonsine Tables and the Copernican Tables that showed the positions of planets at any time. While officially studying the humanities, he purchased more books and instruments that he hid from Vedel, and spent each night observing the heavens.

On August 17, 1563, Tycho observed Jupiter and Saturn passing very close to each other. A check of his tables showed that the Alfonsine Tables were off by a month in predicting the event and the Copernican Tables missed it by a week. He decided it would be his job to create the most accurate tables possible. He began constructing his own instruments; some of his own design, including a radii (a pair of calipers) made of wood with the degrees divided by transversals. Back home, Jørgen died of pneumonia after jumping into one of the canals of Denmark to rescue King Frederick II from drowning. Rumor has it, the king, a heavy drinker, had been drunk at the time. After a brief visit at home Tycho went to Wittenburg to study mathematics and astronomy but was forced to hastily leave the city because of the plague. He turned up at the University of Rostock, where he fought a duel with a Danish nobleman. The argument, which may have been over who was the better mathematician, cost Tycho part of his nose sliced off by a sword. He commissioned a jeweler to make him a brilliant new nose of gold and silver alloy insert, which he wore for the rest of his life. Tycho would often unsettle visitors by taking off the insert and cleaning it while at meals. The duel essentially ended Tycho's stay at Rostock. He spent a few months at the University of Basel in 1568, but then it was back home to meet his destiny.

Tycho became famous throughout Europe for his discovery of a nova (a term he coined for what is now called Tycho's supernova) in Cassiopea in 1572. He thus became the first to record the appearance of a supernova. The star was so bright; it could be seen even in the daytime. The significance of this discovery was that it contradicted the Aristotelian and Scholastic dogma of the invariability of the heavens. The terms nova and supernova, which respectively refer to a "new" star and an extremely bright star, are misleading. These stars are not new, they are ancient and as far as brightness is concern, this is only relative to other stars. Around this time, Tycho made an observation of a lunar eclipse and found the perigee of the Sun. In 1577 he measured the parallax of a comet, enabling him to show that it was farther away than the Moon. This conflicted with accepted Aristotelian theory that held that comets were merely atmospheric phenomena taking

place in the sublunar sphere. Fearful of losing Europe's premier astronomer, King Frederick II offered Tycho the island of Hven in Copenhagen Sound, as well as a handsome yearly stipend, to conduct astronomical researches. Three miles long, flat with white cliffs, Hven is near Hamlet's castle of Elsinore. Tycho hired a German architect to build his Uraniborg castle, named after Urania, the Goddess of the sky. His observatory soon was the best in Europe. He maintained a staff of instrument makers whom he closely supervised, established a printing press, a paper mill, and an alchemist's furnace in the basement of his castle as well as a second underground observatory with isolated stations to ensure reliable independent multiple astronomical measurements. Tycho trained a generation of young astronomers in the art of making astronomical observations.

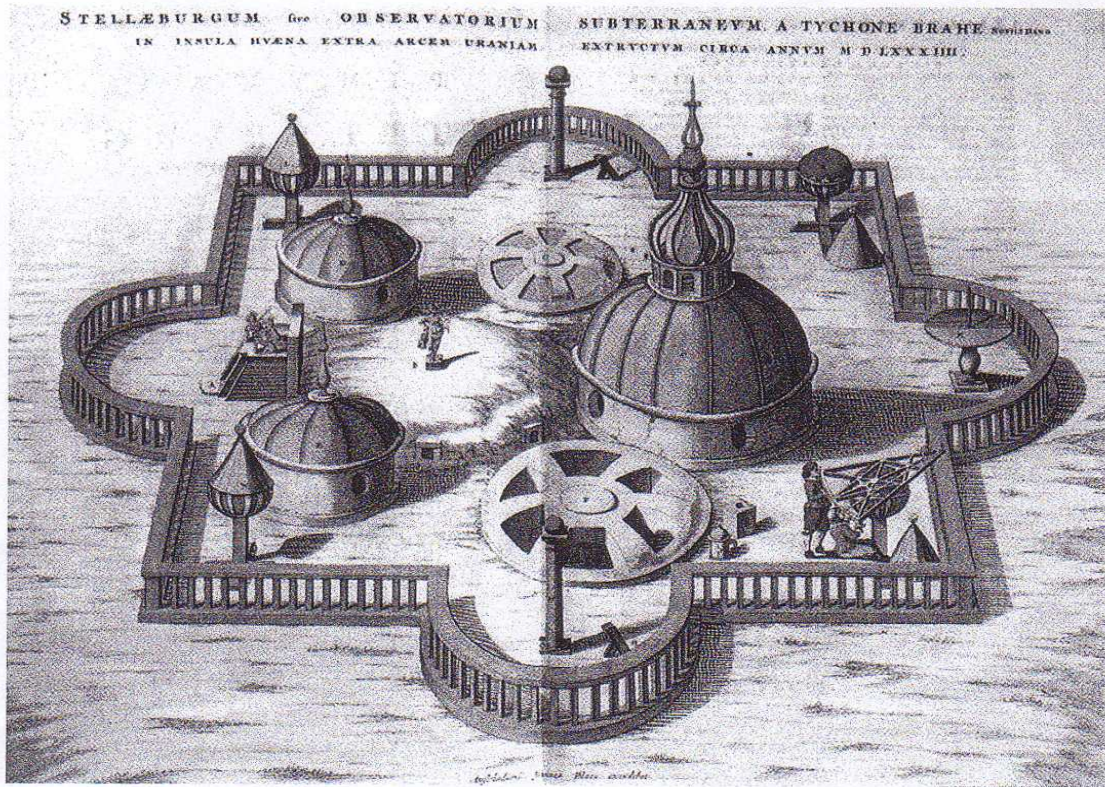
After twenty years, Tycho had a run in with the new king, Christian IV, who wished to cut the astronomer's stipend. Tycho closed the observatory, packed up his instruments, and set out to find a new sponsor. In 1599 he was appointed Imperial Mathematician in the court of the Holy Roman Emperor, Rudolph II at Prague. Tycho was provided with the castle Benatky for his work and when this proved unsuitable, Rudolph gave him a house in Prague. Kepler wrote Tycho asking permission to examine his planetary observations so he might perfect his theory. Tycho replied immediately: "Come, not as a stranger, but as a very welcome friend; come and share in my observations with such instruments as I have with me, and as a dearly beloved associate." He hired Kepler as his assistant but it was not to be a harmonious collaboration because of their conflicting views about the nature of the solar system. When Tycho observed the elongated path of a bright comet, it caused him to question the two current models of the solar system. He rejected the Copernican model, offering an intermediate position between it and the Ptolemaic model. His calculations led him to conclude that if the Earth moved, the stars must be at least 700 times farther from Saturn than the latter is from the Sun. (Actually, the nearest star is more than 40 times his number from Saturn than Saturn is from the Sun). He reasoned that God would not waste that much space in His harmonious, elegant universe. His system did away with the planetary spheres and kept the Earth, with its Moon in orbit, at the center of the Universe and the Sun revolving around it. But he compromised by asserting that the other planets orbit the Sun and are pulled along around the Earth with it [Figure 10.14]. Kepler, on the other hand, was a converted and convinced Copernican. Tycho always regarded his table of planetary motions to be his life's work and when his end was near, they were not completed. On his deathbed he entrusted the completion of them to Kepler, who dutifully accepted the charge. Kepler recorded Brahe's last words: "May I not seem to have lived in vain."



**Tycho Brahe's Planetary Model**  
**Fig. 10.14**

Hard drinking Tycho gave tremendous feasts for his guests on Hven. He would occasionally interrupt the revelry and demand that one and all listen to the musings of a dwarf named Jepp, who he believed had second sight. Tycho also kept a tame deer that died one night after stumbling down a flight of stairs from having consumed too much beer. Legend has it that Tycho died of a burst bladder caused by too much imbibing at a banquet, because he refused to violate etiquette by leaving the table before his guests. The real cause of his illness was probably due to acute prostatitis. He died eleven days later of ureamia (urine in the blood), possibly due to poisoning with heavy metals. Mercury was found in his hair shortly after his death. He is buried in the Tyn-church in Prague. On his tombstone is written: "Neither power nor wealth, only Art and Science will endure." The castle Uraniborg and the observatory were destroyed within a few years of Tycho's death. Surrounded by a carefully organized garden and a square wall 250 feet on a side, the Uraniborg castle [Figure 10.15] had an onion dome and an Italianate palace façade. Tycho designed a zodiacal armillary sphere, five feet in diameter, on which the positions of stars were engraved as they were measured over a 25-year period. The quadrant in his study was built into the wall. It was centered over an open window through which observations were made. Several clocks were used simultaneously to try to time the observations as precisely as possible.





**Uraniborg Castle Observatory**  
**Fig. 10.15**

Like many early astronomers, Tycho dabbled in astrology. At the time there were more professors of astrology than of either medicine or astronomy at universities. It was considered a legitimate science that played an important role in alchemy, another legitimate science. Tycho appears to have believed that heavenly bodies influenced but did not cause terrestrial events. Apparently his forays into astrology were at the behest of his patrons Frederick II and Rudolph II. Tycho once forecast the date of Suleiman the Magnificent's death, only to discover that Suleiman was already dead. His wife was Kirstin Jørgensdatter, although they were never married in a church, because the law did not allow marriages between nobility and commoners. They had three sons and five daughters.

Quotation of the Day: "Not to be seen but to be." – Tycho Brahe's motto