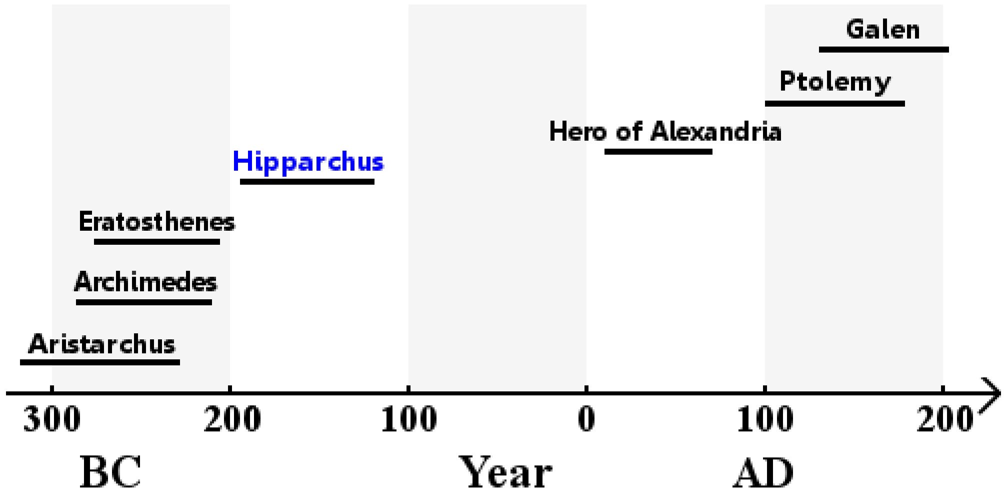
HIPPARCHUS



Hipparchus (or **Hipparchos** was born in Nicaea, Bithynia and died after 127 BC), was a Greek astronomer and mathematician who made fundamental contributions to the advancement of astronomy.As a young man in Bithynia, Hipparchus compiled records of local weather patterns throughout the year. Such weather calendars (*parapēgmata*), synchronized the onset of winds, rains, and storms with the astronomical seasons and the risings and settings of the constellations

Most of Hipparchus's adult life, however, seems to have been spent carrying out a program of astronomical observation and research on the island of Rhodes.

Hipparchus's most important astronomical work concerned the orbits of the Sun and Moon, a determination of their sizes and distances from the Earth, and the study of eclipses. Like most of his predecessors—Aristarchus of Samos was an exception—Hipparchus assumed a spherical, stationary Earth at the centre of the universe (the geocentric cosmology). From this perspective, the Sun, Moon, Mercury, Venus, Mars, Jupiter, and Saturn (all of the solar system bodies visible to the naked eye), as well as the stars (whose realm was known as the celestial sphere), revolved around the Earth each day.

Hipparchus knew of two possible explanations for the Sun's apparent motion, the eccenter and the epicyclic models (Ptolemaic system). These models, which assumed that the apparent irregular motion was produced by compounding two or more uniform circular motions, were probably familiar to Greek astronomers well before Hipparchus. His contribution was to discover a method of using the observed dates of two equinoxes and a solstice to calculate the size and direction of the displacement of the Sun's orbit. With Hipparchus's mathematical model one could calculate not only the Sun's orbital location on any date, but also its position as seen from the Earth. The history of celestial mechanics until Johannes Kepler (1571–1630) was mostly an elaboration of Hipparchus's model.

Hipparchus also tried to measure as precisely as possible the length of the tropical year—the period for the Sun to complete one passage through the ecliptic. He made observations of consecutive equinoxes and solstices, but the results were inconclusive: he could not distinguish between possible observational errors and variations in the tropical year. However, by comparing his own observations of solstices with observations made in the 5th and 3rd centuries BC, Hipparchus succeeded in obtaining an estimate of the tropical year that was only 6 minutes too long.

Hipparchus also analyzed the more complicated motion of the Moon in order to construct a theory of eclipses. In addition to varying in apparent speed, the Moon diverges north and south of the ecliptic, and the periodicities of these phenomena are different.

The Earth-Moon Distance

In *On Sizes and Distances* (now lost), Hipparchus reportedly measured the Moon's orbit in relation to the size of the Earth. He had two methods of doing this.

- One method used an observation of a solar eclipse that had been total near the Hellespont (now called the Dardanelles) but only partial at Alexandria. Hipparchus assumed that the difference could be attributed entirely to the Moon's observable parallax against the stars, which amounts to supposing that the Sun, like the stars, is indefinitely far away. (Parallax is the apparent displacement of an object when viewed from different vantage points). Hipparchus thus calculated that the mean distance of the Moon from the Earth is 77 times the Earth's radius.
- In the second method he hypothesized that the distance from the centre of the Earth to the Sun is 490 times the Earth's radius—perhaps chosen because that is the shortest distance consistent with a parallax that is too small for detection by the unaided eye. Using the visually identical sizes of the solar and lunar discs, and observations of the Earth's shadow during lunar eclipses, Hipparchus found a relationship between the lunar and solar distances that enabled him to calculate that the Moon's mean distance from the Earth is approximately 63 times the Earth's radius. (The true value is about 60 times.)

How long is a Year?

To make an accurate, consistent calendar, we need to know how long the tropical year is – the exact amount of time between one summer solstice and the next one. This is difficult to measure accurately.

Hipparchus made careful observations and got a better value than anyone before him. His final figure was only 6 minutes too high.

"I have composed a book on the length of the year in which I show that the tropical year contains 365 days plus a fraction of a day which is not exactly $^1/_4$ day as the mathematicians-astronomers suppose, but which is less than $^1/_4$ by about $^1/_{300}$."

Star Catalog

Hipparchus completed a star catalog of about 850 stars in 130 BC. He also constructed a celestial globe, showing the constellations and stars arranged on a sphere.

In his catalog he specified the positions of stars and recorded their relative brightness (magnitude) on a 1 to 6 scale, where 6 is barely visible and 1 is very bright. Astronomers today continue to use a similar system for star magnitudes.