Early Astronomers

Nicholas Copernicus (1473-1543)

- Devised a heliocentric model in which the planets, including the Earth, moved in orbits about the central Sun. Deposing the Earth from its central and static position constituted the "Copernican Revolution." (The Ptolemaic system, in contrast, was geocentric andgeostatic.)
- This system is simpler than Ptolemy's - and explains planetary brightness variations as well as motions.
- In the Copernical system the celestial sphere was fixed and unmoving, dirunal motions now being accounted-for by the Earth's (eastward) rotation about its axis

Tycho Brahe (1546-1601)

- Made extremely accurate (<1' errors) measurements of stellar and planetary positions.
- Determined the year's length to within a second.
- Triangulation attempts on Tycho's Nova and a comet showed that both objects were more distant than the Moon - *i.e.* these were truly astronomical objects.
- Employed Johannes Kepler to assist in analyzing this information.
- Constructed the "Tychonic System", a hybrid of the Ptolemaic and Copernican Systems. (In Tycho's System the Sun and Moon went around the Earth, as in the Ptolemaic System, but the planets went around the Sun, as in the Copernican System.)

Thomas Digges (1546-1595)

- Argued that the stars were probably like the Sun but dispersed in space at very great distances (not all "on" a single celestial sphere.).
- Noted that Tycho's failure to measure their parallaxes indicated that they were at least 1700 times the Sun's distance. It was therefore not surprising that Aristotle was unable to detect the parallactic motion.

Johannes Kepler (1571-1630)

- Analyzed Tycho's data on planetary positions and tried to fit them with Ptolemaic or Copernican systems of epicycles. Failed. Proceeded to derive orbital shapes and motions from the observations.
- Formulated "Kepler's Laws" of planetary motion, the first two largely based upon observations of Mars from Tycho's data.
- Produced a substantially correct description of planetary motions, finalizing the efforts begun by Ptolemy and continued by Copernicus. (Planetary motions are neither circular nor uniform.)

Galileo Galilei (1564-1642)

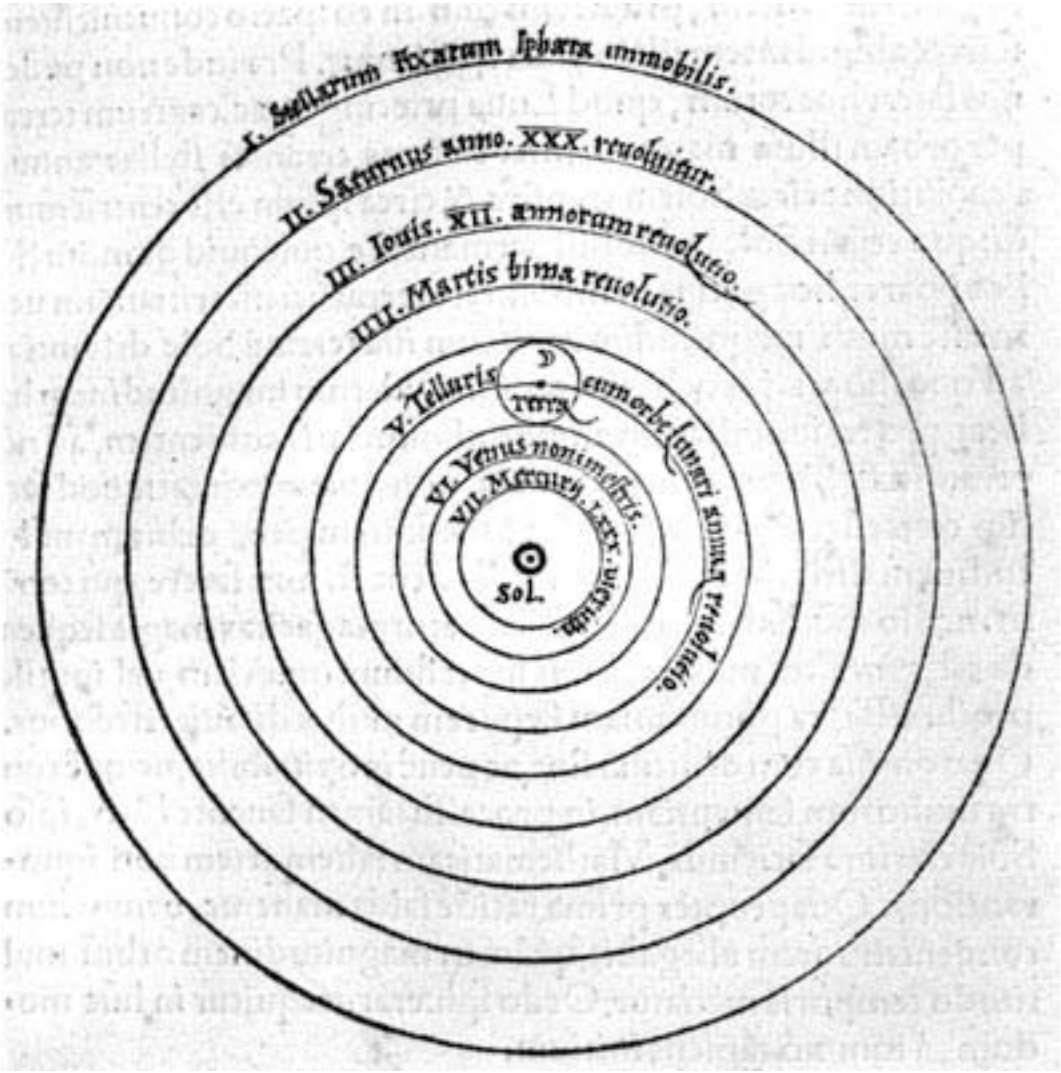
- The first great experimentalist. Performed experiments in "mechanics" which largely disproved Aristotelian beliefs. Described " inertia", behavior of falling bodies.
- Constructed (and marketed) telescopes. Used these for astronomical observations.
- Observed mountains, craters, and other topography on the surface of the Moon.
- Discovered four moons of Jupiter (the "Galilean satellites") and observed their motions about Jupiter.
- Observed markings on Mars and Jupiter and noted that these bodies rotated about their axes.
- Discovered Saturn's rings. (But never really figured out what it was he was seeing.)
- Observed sunspots and by watching them discovered the Sun's rotation.
- Discovered that the Milky Way and some "nebulae" to be stars and clusters. (*cf.* Democritus)
- Observed gibbous phases of Venus, thus disproving the Ptolemaic model. Further, his observations provided strong support for the heliocentric Copernican/Keplerian view.

Isaac Newton (1642-1727)

- Experimentalist. Experiments in mechanics, fluid mechanics, optics. Established many of the fundamental physical principles in these areas. Built telescopes of new types – I ncluding reflectors.
- Formulated "Newton's Three Laws of Motion" which describe how any object of known properties (*e.g.* of known mass) will move under the influence of any known force.
- Discovered/formulated the "Law of Gravity". Gravity os one of four fundamental forces of nature.
- Showed that Kepler's Laws (generalized and slightly corrected) were consequences of the nature of the gravitational force - and applied to situations other than just the Sun and planets.
- Invented the calculus, a powerful mathematical tool he needed for doing these calculations.

The Copernican System

From: De Revolutionibus Orbium Coelestium (1543)



If viewed from above the Earth's Northern Hemisphere all orbital motions in this figure are counterclockwise - including that of the Moon.

The Earth's diurnal rotation about its axis is also counterclockwise - or eastward. (The sidereal day is 23h 56m 04s.)

The small epicycles associated with each planet's orbit, and that of the Moon, are not shown. The orbits are actually ellipses. Also, the figure is not to scale.

The orbital periods, in years, of the planets known to Copernicus are: Mercury = 0.38, Venus = 0.61, Earth = 1.00, Mars = 1.88, Jupiter = 11.86, and Saturn = 29.46

The stars lie on the immobile celestial sphere represented by the outermost circle in this figure. (In fact, the axial rotations of all of the bodies shown - except for Venus - are also clockwise or "eastward".)