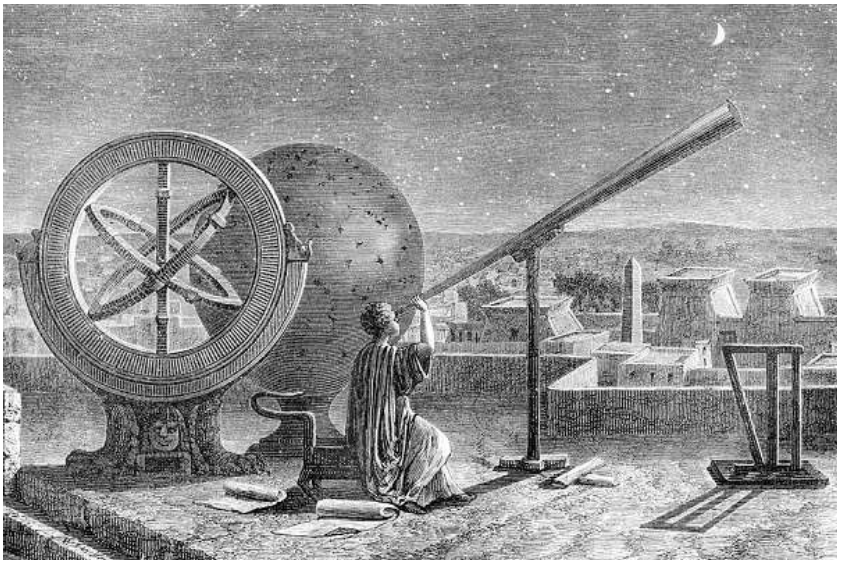
Astronomy of the Middle Ages

Ptolemy's Universe



Since ancient times, Astronomy was an important field of study and part of the **Quadrivium**, studied by all University students. Until the 15th century, Ptolemy's model of a geocentric Universe, incorporating all astronomical research and measurements noted until up to the 2nd century, was considered a reliable guide for mariners, travelers, and astronomers alike. The idea of a heliocentric universe had been proposed in ancient times (Aristarchus of Samos, 250 B.C.) but ancient astronomers objected on the grounds that no parallax shift in the location of the stars was visible over the course of a year. The ancients well understood the mathematics of using trigonometry to estimate distances, but could detect no shift in the stars location that would indicate movement of the earth relative to the sun, so they ruled out a heliocentric model based on the best science of the day.

Buridan to Copernicus (1340-1540)

By the Middle Ages, interest in astronomical studies re-emerged, especially in the monasteries and universities. During the 14th and 15th centuries, various philosophers made proposals regarding the nature of the Universe and the motion of planets, but many theories relating to the motion of planets and celestial objects were merely speculation since there were not obvious ways to prove one's theory. The custom was to discuss possibilities without drawing conclusions or directly contradicting scriptures. The church saw now harm in theories, even outlandish ones, as long as they were not presented as fact. In the early 14th century, 200 years before Newton revolutionized the science of astronomy, Jean Buridan and Albert of Saxony proposed the idea of *impetus* (a concept similar to Newton's inertia), to explain the movement of planets. Soon after Nicholas Oresme proposed that the earth spun on its access and provided some important proofs, while Nicholas of Cusa proposed the possible existence of other worlds and a non-geocentric universe. All of these ideas were discussed and debated openly without being restricted by the Catholic Church.

In 1543, in an atmosphere of open scientific dialogue, Copernicus published "On the Revolution of Heavenly Spheres" promoting his theory of a heliocentric universe. His work was mathematical, intended for scholars rather than the general public, and was received without particular controversy. It was not until 70 years during the Galileo controversy that the book was held to be controversial and placed on the list of Forbidden books.

Jean Buridan *(c. 1300 – after 1358)*	French priest who formulated early ideas of momentum and inertial motion and sowed the seeds of the Copernican revolution, over 200 years before Newton formalized laws of motion.

Albert of Saxony *(c. 1320–1390)*	German bishop known for his contributions to logic and physics; with Buridan he helped develop the theory that was a precursor to the modern theory of inertia.
Nicole Oresme *(c. 1323–1382)*	French bishop and one of the most influential philosophers of the 14th century; economist, mathematician, physicist, astronomer, philosopher, and theologian. Established proof the Earth rotates on its axis.
John Cantius *(1390–1473)*	Polish priest, scholastic philosopher, and mathematical physicist who studied the theories of Buridan and further developed the theory of impetus.
Nicholas of Cusa *(1401–1464)*	Cardinal, philosopher, jurist, mathematician, astronomer, and one of the great geniuses and polymaths of the 15th century. Highly respect scholar who proposed the possibility of multiple worlds and a non-geocentric universe.
Nicolaus Copernicus *(1473–1543)*	Polish Canon and Renaissance astronomer famous for his heliocentric cosmology that set in motion the Copernican Revolution.

Tycho Brahe to Newton (1580-1680)

In the 70 years between Copernicus and Galileo, telescope technology improved considerably, and it was the largely the ability to see moons orbiting other planets in the solar system that made Galileo certain that the Copernican model was correct, even though there were numerous unresolved problems with it. (Copernicus failed to explain the problem of parallax, and his circular orbits were inaccurate). The Galileo controversy has been blown out of proportion by anti-Catholic historians. The real story of Astronomy owes much more to the efforts of Tycho Brahe, and Kepler, both contemporaries of Galileo, than it does to the controversialist.

While Galileo was stirring up trouble and controversy, and polarizing the entire field of Astronomy, Kepler and Brahe worked quietly in Prague, making meticulous and extremely accurate measurements of planetary motion over thirty years that proved indispensable to Newton several generations later. Kepler started his career as an assistant to Brahe, but while Brahe sought to combine both the Copernican and Ptolemaic models to create a hybrid system (the planets orbit the sun, but the sun orbits a stationary earth), Kepler used the highly accurate data to propose a Copernican-like system with elliptical rather than circular orbits. Kepler's master work, "The New Astronomy" was published in 1609. It was a much improved version of the Copernican theory, this time without the problems presented by circular orbits, and with the benefit of a great deal of new observational data.

It was largely Kepler's work that inspired the landmark studies of Isaac Newton, but the contributions of other Catholic scholars were also very important. Buridan proposed that motion of Planets was self-sustaining; Oresme proposed rotating planets; several thinkers had proposed that outer space was a frictionless, Jean Picard had created methods of measuring the earth to an extreme degree of accuracy, and Riccioli had accurately measured the acceleration of gravity. But no one had the audacity to assert that the exact same force of gravity that controlled the motion of earthly objects also operated in space. It was a radical theory, but Kepler's measurements were accurate enough to prove the theory was sustainable and predict precisely the elliptical orbits observed. The whole idea of "universal" laws that effected all matter at all time was positively earth-shaking, and was the true engine of the Scientific revolution.

Christopher Clavius *(1538–1612)*	German Jesuit mathematician and astronomer, most noted in connection with the Gregorian calendar, his arithmetic books were used by many mathematicians including Leibniz and Descartes.
Tycho Brahe *(1546-1601)*	Protestant Astronomer, who worked with Kepler. His extremely accurate measurements astronomical measurements set standard of accuracy that was critical in developing theories of planetary motion. He believed (due to lack of parallax) in a stationary earth, so developed a hybrid model of the Universe that was accepted by Catholic astronomers for some years.
Galileo Galilei *(1564–1642)*	Italian Layman polymath and astronomer whose arrest and trial by the inquisition is a mythological basis of the science vs. faith 'conflict' thesis.
Johannes Kepler *1571-1630)*	Protestant Astronomer who began as an assistant to Tycho Brahe. Continued Brahe's careful observations and eventually wrote a book 'New Astronomy' proposing that planets moved in elliptical orbits. His theories and careful measurements were critical to Newton's theory of Universal gravitation.
Niccolò Zucchi *(1586–1670)*	Jesuit astronomer and associate of Kepler. Described the principles of building a reflecting telescope in 1616 using a curved mirror. May have been the first to see the belts on the planet Jupiter.
Giovanni Battista Zupi *(c. 1590–1650)*	Jesuit astronomer, mathematician, and first person to discover that the planet Mercury had orbital phases; the crater Zupus on the Moon is named after him.
Pierre Gassendi *(1592–1655)*	French priest, astronomer, and mathematician who published the first data on the transit of Mercury; best known intellectual project attempted to reconcile Epicurean atomism with Christianity.
Alexius Polonus *(1593 – c. 1653)*	Jesuit astronomer who studied sunspots and published a work on calendariography.
Giambattista Riccioli *(1598–1671)*	Jesuit astronomer who authored *Almagestum Novum*, (The New Almagest), an illustrated encyclopedia of Astronomy that became a standard reference for the 17th and 18th centuries. Also First person to measure the rate of acceleration of a freely falling body; created the first map of the moon surface with Father Grimaldi.
Jean Picard *(1620–1682)*	Jesuit priest and first person to accurately measure the size of the earth; developed standard method for measuring ascension of a celestial object. His accurate measurements were of critical importance to proving Newton's theories.
Giovanni Cassini *(1625–1712)*	Layman astronomer, first to observe four of Saturn's moons and the co-discoverer of the Great Red Spot on Jupiter.
Isaac Newton *(1642-1726)*	British scientist who developed a set of physical laws that could account for the motion of planets in the heavens as well as objects on earth. He also helped define Calculus and made major contributions to the fields of Optics. He was a devout (but somewhat heretical) Christian and wrote more papers on theology than on physics.

After Newton (1700+)

The reason Newton's laws of universal gravitation, and mathematical representations of force, mass, acceleration, and momentum were so important was that they now provided a framework within which other abstract quantities, such as pressure, and temperature could be measured and understood. The certainty that all mass, whether in liquid or solid form, whether a rock or a planet, was subject to physical laws, opened the door to sustained and systematic scientific investigation.

In the centuries after Newton's discoveries, Catholic scientists, especially Jesuits, continued to make remarkable discoveries. Even up to the 20th century, Cleric-scientists have contributed enormously to the understanding of the solar system. In 1927 a Belgian priest proposed that the Universe originated with a 'Big Bang' whose radioactive footprint was still visible. Although scorned by many of the scientists of his day, including Einstein, Lemaitre has been proven right.

Léon Foucault *(1819–1868*	Layman astronomer invented the Foucault pendulum to measure the effect of the earth's rotation.
Georges Lemaitre *(1894–1966)*	Belgian priest and father of the Big Bang theory.