

HISTORY OF ASTRONOMY

ANCIENT ASTRONOMY

- Ancient cultures used the nighttime sky
 - Arrival of seasons
 - Astronomical events (eclipse)
 - Seafarers-navigation
 - Farmers-planting crops
- Constellations-way to label regions of celestial sphere
- Large and elaborate structures were built as calendars for the night sky

STONEHENGE

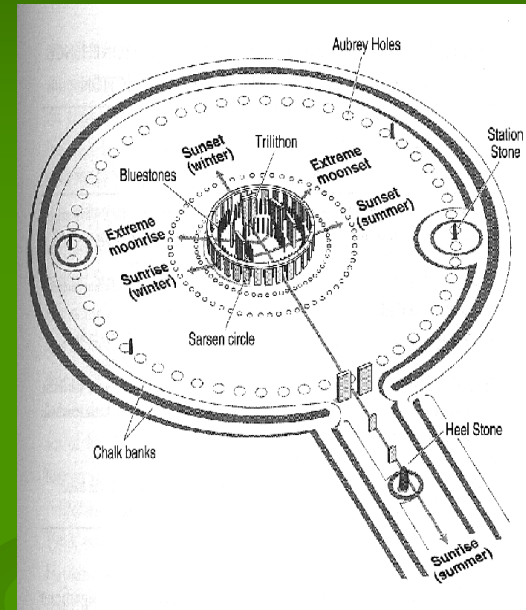
- Salisbury Plain in **England**
- Believed to be an **early astronomical observatory**:
 - Used as a calendar or almanac
 - Identifies important dates through specific celestial events
- Built from **2800 B.C. to 1100 B.C.** (17 centuries)
- Largest stones weigh 50 tons and were brought from many miles away





ASTRONOMICAL STONE ALIGNMENT

- Many of the stones are aligned so that they point toward important astronomical events
- The line joining the center of the inner circle to the heel stone points in the direction of the rising Sun on the summer solstice (the longest day of the year)
- Alignments are related to the rising and setting of the Sun and the Moon at various other times of the year



BIG HORN MEDICINE WHEEL

- In Wyoming
- Used by Plains Indians
- Spokes are aligned with risings and settings of the Sun and other stars
- 10,000 ft atop Medicine Mountain



CARACOL TEMPLE

- Near Cancun, Mexico
- Built by the **Mayans** around **A.D. 1000**
- Function to keep **track of seasons and the heavens**
- **Windows are aligned** with astronomical events such as sunrise and sunset at the solstices and equinoxes and the risings and settings of Venus
- Believed to be the activities of gods replaying mythical events from the time of Creation



ANCIENT CHINESE

■ Omens

- Comets-considered as omens
- “guest stars”-appeared suddenly and slowly faded away

■ Kept extensive records of events

- 1054 A.D. – best-known “guest star” – visible in daytime sky for many months– actually a supernova (star death)
 - Part is still detectable today – 9 centuries later



- Jesuits teaching astronomy in Chinese court

ANCIENT CHINESE

- In ancient China, an astronomical observatory was usually built inside the capital city
- Trained astronomers were appointed to keep a diligent watch of the sky day and night
- They recorded important events (eclipses, comets, "new" stars...)



ARABIC ASTRONOMERS

- New instruments
 - Compass
 - Rockets
- Mathematics
 - Trigonometry
 - Determine the precise dates of holy days
 - Direction of Mecca from any given location on Earth
- Astronomical terms
 - Zenith (point overhead)
 - Azimuth (angle from the North)
- Star names
 - Rigel, Betelgeuse, Vega



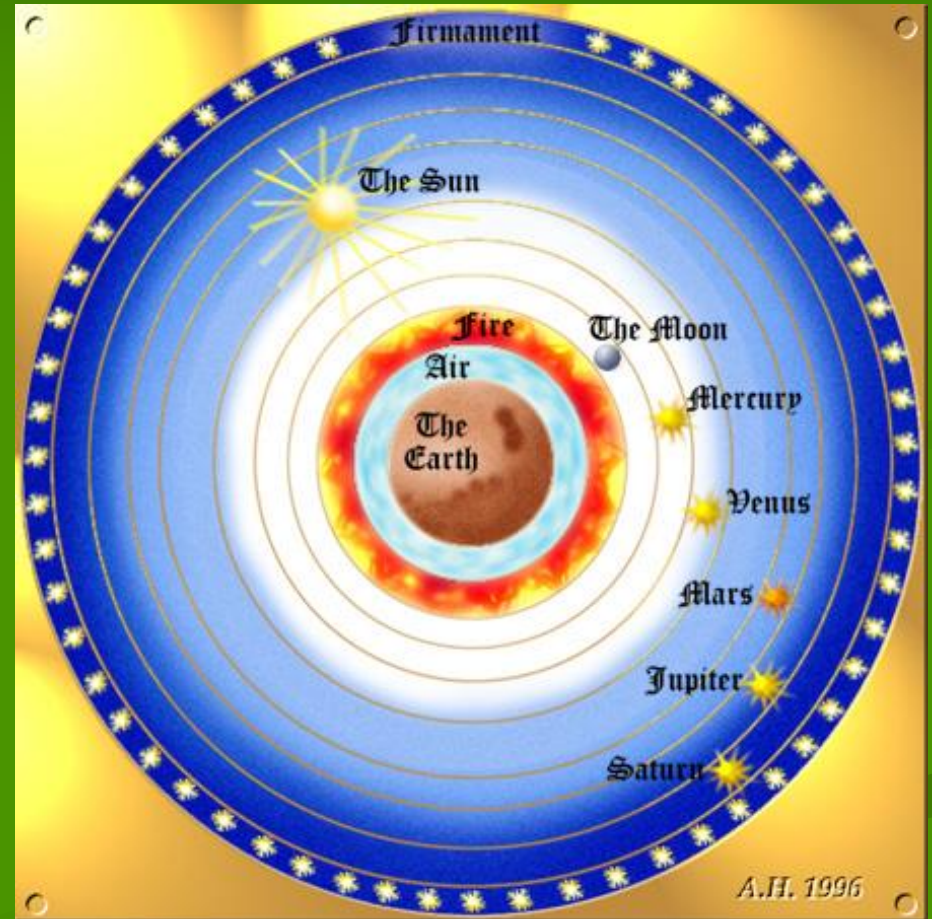
COSMOLOGY

- Study of the workings of the universe on the largest scale
- Today, cosmology entails looking at the universe on scales so large that even entire galaxies can be regarded as mere points of light scattered throughout space
- To the Greeks, however, the universe was the Sun, Earth, Moon, Mercury, Venus, Mars, Jupiter, and Saturn



GEOCENTRIC UNIVERSE

- One of the earliest models of the solar system
- Developed by Greek philosopher **Aristotle**
- **Earth is at the center** of the universe
- All other bodies move around it in uniform motion

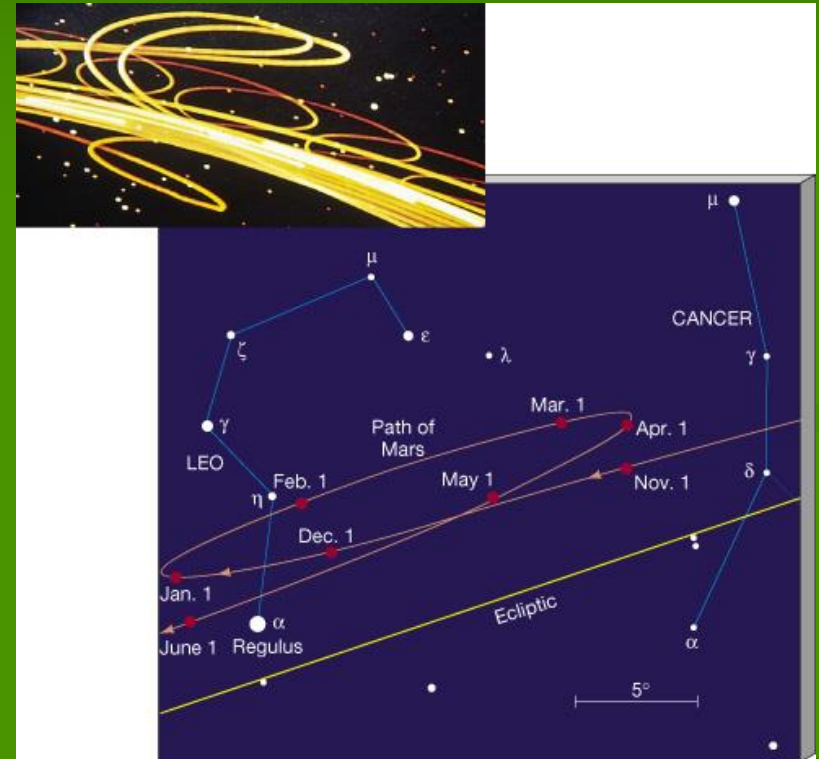


PLANETS

- Planets do not behave in as regular and predictable a fashion as the Sun, Moon, and stars
- They vary in brightness, and they don't maintain a fixed position in the sky
- They seem to speed up and slow down during their journeys, and at times they even appear to loop back and forth relative to the stars

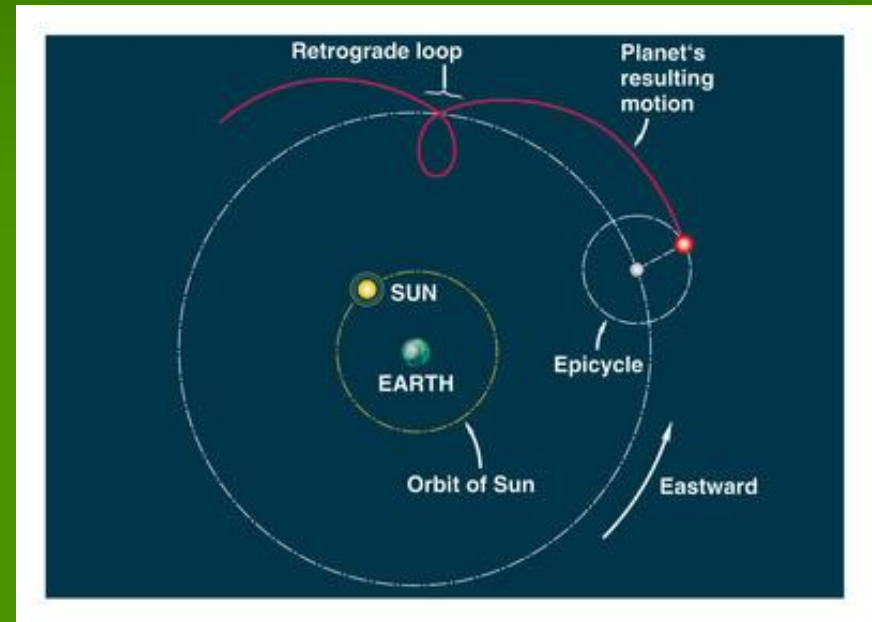
PROBLEMS WITH GEOCENTRIC MODEL

- Geocentric model could not account for:
 - Variations in planetary brightness
 - The planets produce no light of their own
 - Retrograde motion
 - There are periods when a planet's eastward motion stops and the planet appears to move westward in the sky for a month or two before reversing direction again and continuing on its eastward journey
 - <http://www.astro.uiuc.edu/projects/data/Retrograde/>



MORE COMPLEX MODEL

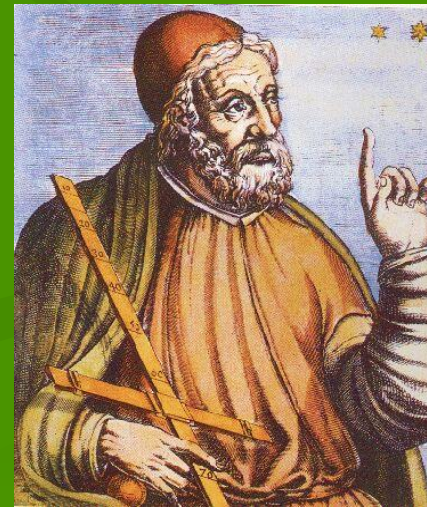
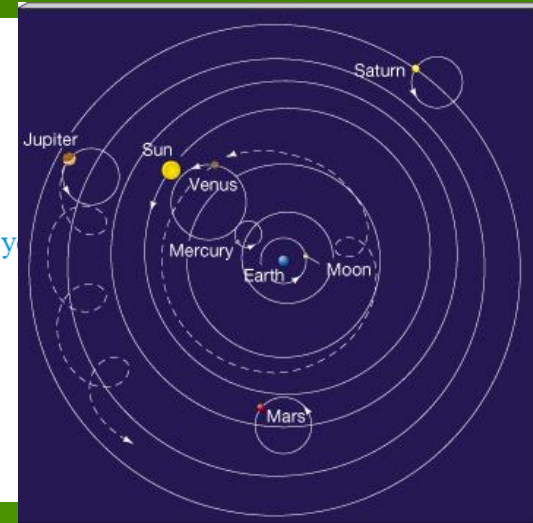
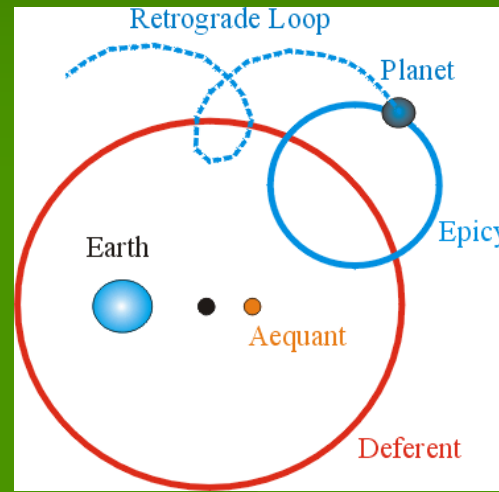
- New model developed
 - Each planet moves around a small circle called an epicycle
 - Epicycle center moves uniformly around Earth on a second larger circle known as the deferent
 - Motion composed of 2 separate circular orbits



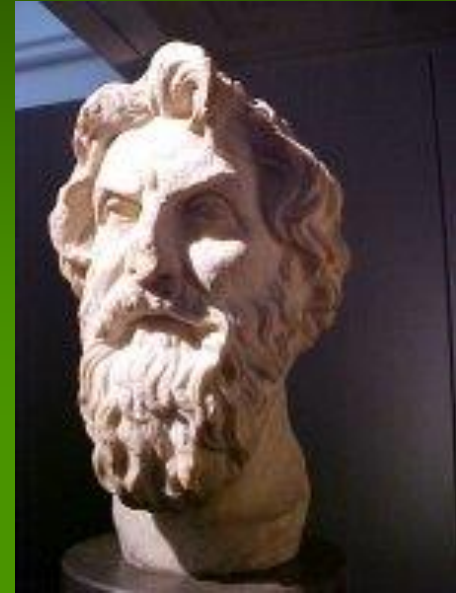
<http://www.astro.utoronto.ca/~zhu/ast210/geocentric.html>

PTOLEMY'S MODEL

- A.D. 140
- Explained paths of the 5 known planets, Sun & Moon
- Eccentric = true center (black dot)
- Planet moves uniformly in relation to the aequant (orange dot)
- Required 80 circles to account for the paths
- <http://webpages.charter.net/middents/Ptolemy's%20Model.htm>



ARISTARCHUS

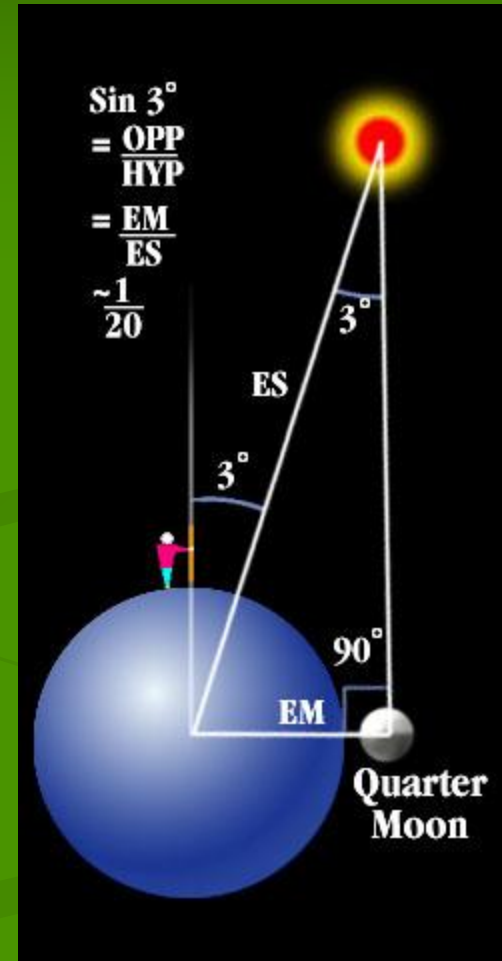


- The first to propose a **heliocentric** or **sun-centered** theory of the universe
- Used **eclipses** to estimate the sizes and distances of the Earth, Moon and Sun.
- Looked at the Earth's shadow on the Moon during a lunar eclipse
- Curve of the Earth's shadow on the Moon indicated that the Earth is larger than the Moon-- over twice the size
- The Moon's shadow on the Earth was smaller because solar eclipses were rare events and observed in some parts of the extensive Greek Empire but not other areas
- Solar eclipses showed that the Earth had to be much bigger than the Moon



ARISTARCHUS

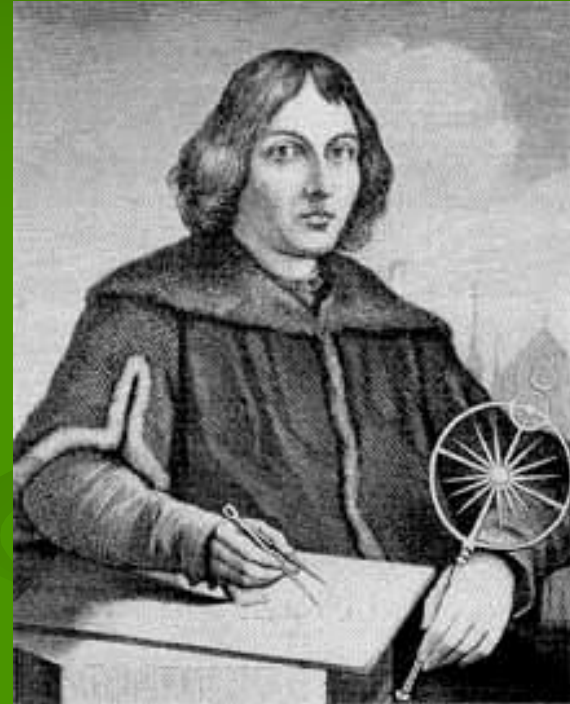
- Measured distance to the sun with geometry
- Showed the Sun was 20 times farther from the Earth than the moon
- Helped show the sun was the center of the universe
- His ideas were not accepted until 16th century because Aristotle had too much influence



RENAISSANCE SCIENCE

COPERNICUS

- Ptolemy's model of the universe survived for 13 centuries
- Rediscovered Aristarchus's heliocentric model



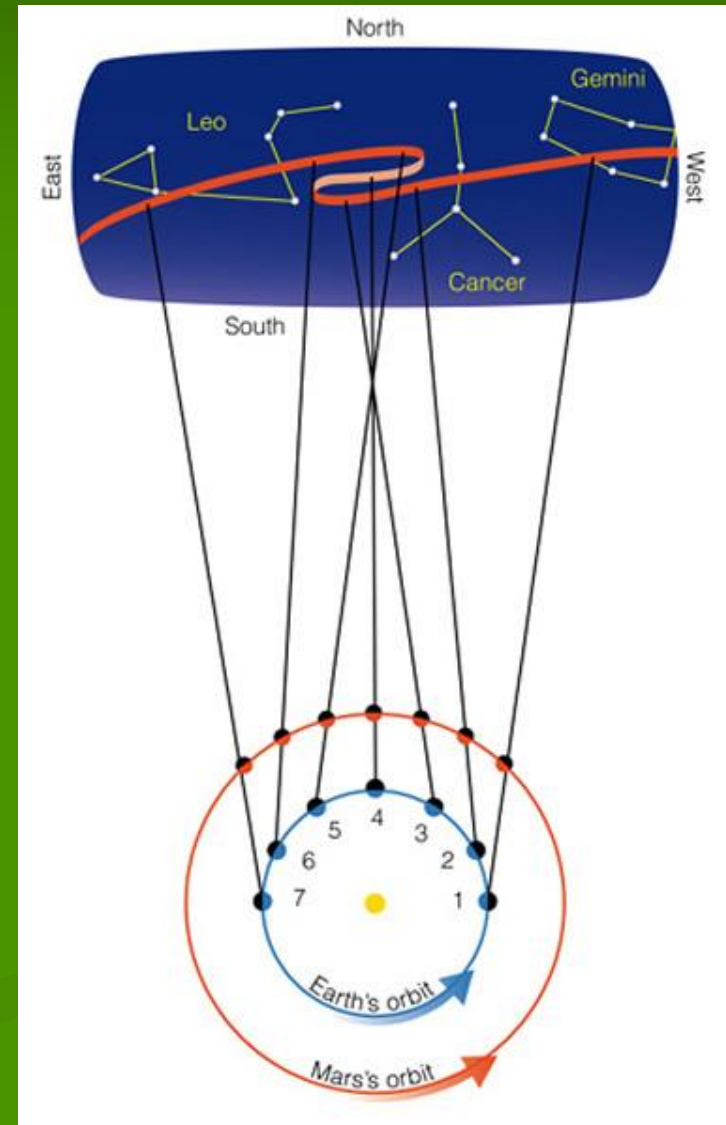
COPERNICAN REVOLUTION

Foundations:

1. Earth is not at the center of everything
2. The center of Earth is not the center of the universe – it's the center of gravity & lunar orbit
3. All planets revolve around the Sun
4. The stars are farther away than the sun
5. Apparent motion of the stars is a result of Earth's motion
6. The motions of Earth are responsible for the Sun's daily and yearly motion
7. Heliocentric model explains the retrograde motion of the planets

RETROGRADE MOTION


- When Earth & Mars are close – Mars is brighter
- When farther apart – appears dimmer
- Because line of sight from Earth to Mars changes as the planets orbit Sun, Mars looks like it loops back & forth in retrograde motion
- Line of sight changes because Earth moves faster in orbit than Mars
- <http://csep10.phys.utk.edu/astr161/lect/retrograde/copernican.html>
- <http://www.lasalle.edu/~smithsc/Astronomy/retrograd.html>



UNACCEPTED MODEL

- Neither his fellow scholars nor the general public easily accepted Copernicus's model
- Renaissance science was a time when logic and deduction were seen as secondary to intuition and emotion.
- **Heliocentricity violated many of the religious teachings of the time**
 - It demoted Earth to a noncentral and undistinguished place within the solar system and the universe
- Copernicus's work had little impact on the general populace of his time, at least in part because it was published in Latin (the standard language of academic discourse at the time), which most people could not read
- Only long after Copernicus's death, when others popularized his ideas, did the Roman Catholic Church take them seriously enough to bother banning them

MODERN ASTRONOMY

The background is a solid green color. In the bottom right corner, there are several overlapping, wavy, light green lines that create a sense of motion or depth, resembling a stylized landscape or a decorative graphic element.

GALILEO GALILEI

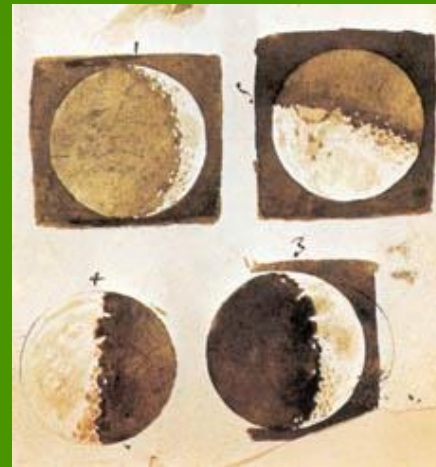
- Italian mathematician and philosopher
- Used the newly invented **telescope** for experimentation
- Built his own telescope in 1609
- View of skies **supported Copernicus**



GALILEO'S DISCOVERIES

- Mountains, valleys, and craters on the Moon
- Sunspots on the Sun (looking at the Sun may have been cause of blindness)
- Determined the Sun rotates about once per month around an axis because of the changing appearance of sunspots from day to day
- Observed the phases of Venus

- Galileo's drawings of the moon and sunspots



GALILEO'S DISCOVERIES

- Saw four small points of light around Jupiter in night sky
- Decided they were moons
- Because another planet was at the center of the moons – supported Copernican model – it proved that Earth is not the center of the universe



GALILEO

- Galileo was directly challenging both the scientific orthodoxy and the religious dogma of his day
- A few years earlier, an astronomer was burned at the stake in Rome for teaching the Earth orbited the Sun



GALILEO

- 1610-published conclusions that supported Copernicus
- 1616-Roman Catholic Church instructed him to abandon astronomical research because it went against literal view of the scriptures
- 1632-published a book that compared Ptolemaic and Copernican models – written in Italian – not Latin, which brought him into direct conflict with the Church
- Forced to retract his claim during the Inquisition
- 1633-placed under house arrest
- 1638-went totally blind
- Remained under house arrest until his death in 1642
- 1992-Church publicly forgave Galileo

PROOF

- Renaissance scholars were correct, but they could not prove that our planetary system is centered on the Sun, or even that Earth moves through space
- Direct evidence for this was obtained only in the early eighteenth century, when astronomers discovered a shift in the observed direction to a star, caused by Earth's motion
- Further verification of the heliocentricity of the solar system came gradually, with innumerable observational tests that culminated with the expeditions of our unmanned space probes of the 1960s, 1970s, and 1980s