The Scientific Revolution: Its Classical and Christian History

with Dr. Ted Davis

Lecture 16: Galileo and the Telescope: Copernicus Vindicated

Outline:

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- The son of wool merchant, lute player, bass singer, composer, and music theorist Vincenzo Galilei (probably late 1520s-1591). Vincenzo carried out experiments on vibrating strings. Galileo may have helped his father with those experiments; his own extensive experience with music may have helped him design some of his own experiments on motion—using music, it would be possible to divide time into small units, before there were any mechanical timing devices that could do it.
    - Vincenzo is credited with inventing a practical approximation locating the frets on a lute for playing a tempered scale, of which he was one of the earliest advocates.
    - His controversial book, Dialogo della musica antica et della moderna (1581), argued against standard ideas in music and for the importance of the major and minor scales used in most Western music today. His son would also write dialogues attacking traditional ideas.
- As a boy, Galileo was educated at the Vallombrosan monastery, southeast of Florence on Monte Secchieta. He nearly decided to become a monk, but his father wanted him to be a physician, so Galileo had to leave.
- Instead, he attended the University of Pisa. He soon found that he liked mathematics more than medicine. He never actually finished his degree—he ran out of money and dropped out.
- Nevertheless, he became a mathematics tutor at the university. He gave two fascinating lectures based on mathematics at the Florentine Academy about the geography of Hell in Dante's Inferno. Starting to make a name for himself, he earned the respect of an important mathematician, Guidobaldo del Monte. At age 25 in 1589, with del Monte's help, he was appointed professor of mathematics at Pisa.
    - But he was not a popular person in Pisa—he mocked conventions, contradicted Aristotle, was arrogant & brash. He thought he would not get tenure there, and he also needed more money after his father died in 1591. So, again with the help of del Monte, he left Florence in 1592 to teach mathematics at Padua—in the Republic of Venice, a foreign country.

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  - However, Galileo still regarded himself as a Florentine, not a Venetian; he followed events in Florence from a distance and subtly ingratiated himself to the ruling Medici family In 1605, he was invited to serve as tutor to the crown prince of Florence, Cosimo II de Medici, during the university vacations; he spent the summer in Florence.
- The first important observational evidence favoring Copernicus did not come until Galileo Galilei (1564-1642) turned his powerful new telescope on the heavens. From observations of Moon, Sun, Jupiter, and Venus, he found evidence that the heavens are just like the Earth – challenging the old hierarchical view of the heavens and the earth.
- Working in the vicinity of Venice, Galileo uses his telescope and his discoveries to advance his career.
- In the summer of 1609 something happened that changed his life forever – the telescope! Galileo heard about it, obtained additional information, and built one for himself. Although Galileo did not invent it, he used it brilliantly – both scientifically and politically.
- Soon after, he started observing the heavens and found breathtaking new things! He rushed into print, publishing his findings just a few weeks after finishing his observations in *Siderus nuncius* (1610). Additional observations were published separately, in *Letters on Sunspots* (1613) and *The Assayer* (1623).
  What did Galileo see?
  - **He sees** craters, mountains, and "seas" on the surface of the Moon.
  - He used them to argue that the heavens are not "perfect".
  - He compares a section of the moon with "a region like Bohemia, if that were enclosed on all sides by very lofty mountains arranged exactly in a circle". (Drake, p. 36)
  - **He notices** that the sky is full of stars, hitherto unseen; the Milky Way is actually a "congeries" of stars, not a nebulous band of white light.
  - **He discovers** four moons orbiting Jupiter. These were used to remove an objection to the Copernican system: there must be multiple centers of motion in the universe, since Jupiter clearly has moons of its own.
    - "We have moreover an excellent and splendid argument for taking away the scruples of those who, while tolerating with equanimity the revolution of planets around the Sun in the Copernican system, are so disturbed by the attendance of one Moon around the Earth while the two together complete the annual orb around the Sun that they conclude that this constitution of the universe is impossible. For…our vision offers us four stars wandering around Jupiter like the Moon around the Earth."
  - Sunspots were also used to argue that the heavens are not "perfect".
  - "Horns" or "ears" on Saturn were seen as well as a full set of phases for Venus. Venus' phases were also used to argue for Copernicus: they show that the Ptolemaic system is wrong – at least for Venus.
    - This shows a decisive argument against the old world system.

- Galileo also uses these new moons to get himself a new job! In a stroke of genius, decides to name the moons of Jupiter after Cosimo, his former pupil, who is now ruling Florence.
- What did others think? Within two years, Jesuit astronomers at the Collegio Romano confirm what Galileo has seen. They don't agree that his observations definitively prove the Copernican theory, but they know they need to take them seriously and wrestle with the implications.
- A pertinent example: In the final edition of his commentary on Sacrobosco (1611-12), the great Jesuit mathematician Christopher Clavius praised the "reliable little book by Galileo Galilei [Sidereus Nuncius], which describes various observations of the stars first made by him."
    - "Since things are thus, astronomers ought to consider how the celestial orbs may be arranged in order to save these phenomena."'
- Everything Galileo saw could be fully understood within an alternative geocentric model proposed many years earlier by Tycho Brahe—without having to put the earth in motion. So, Tycho's system gained substantial support, especially from the Jesuit astronomers but also from many others.
- A crucial example: In his Almagestum novum (1651), Giovanni Battista Riccioli agreed that Ptolemy's system had to be discarded, but the weight of the evidence favored Riccioli's version of Tycho's theory over Copernicus.
    - Ptolemy says, "I am raised [in the balance] in order that I might be corrected."