

Galileo

Astronomer, Anti-anti-Copernican

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Galileo Galilei

- 1564-1642
- Born in Pisa, same year as Shakespeare.
- Son of a prominent musician and music theorist.
- Enrolled at University of Pisa to study medicine, 1581
 - Hated it.



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Galileo, the young mathematics whiz

- While supposedly studying medicine, Galileo became interested in mathematics and began to study it with a tutor
 - Left university without a degree in 1585
- Appointed *professor of mathematics* at Pisa in 1589 at age of 25
 - Salary 1/10 of that of a professor of philosophy
 - Galileo loathed philosophers

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Leaning Tower Experiment

- Galileo gathered a group of academics and townspeople at the Leaning Tower of Pisa to witness a demonstration.
- He dropped metal balls of different weights simultaneously from the tower to demonstrate that Aristotle's assertion that they landed at different times was wrong



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Mathematician in the 16th century

- The profession of mathematician was just evolving in the 16th century and had two different senses:
 1. *Calculating magician* – like Kepler, whose job included casting horoscopes and uncovering the secrets of nature
 2. *Precision engineer* – someone who knew how to aim the cannon, and could make precision instruments. In short, an engineer. This is what Galileo was.

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Galileo proves his worth

- Galileo set up a workshop at the University of Pisa where he invented, made, and sold instruments for industrial and military purposes.
 - With this he supplemented his meagre income and developed a reputation as a fine craftsman and accurate mathematician.

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Galileo gets better job

- Galileo parlayed his reputation at Pisa into a better job.
- He was appointed professor of mathematics at the *University of Padua* in 1592 for 3 times his Pisa salary.
 - Padua was *the* science university of the day.
 - Light teaching duties: Euclid and Ptolemy
- Galileo won over to *Copernican theory* because it could explain the **tides**.

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The Telescope

- Spyglass invented in Holland in 1609, magnification of 3 times
- Galileo sets out to make his own telescope
 - First makes an instrument with 8x magnification
 - Then 20x
 - Ultimately 30x
- Sold telescopes to Venice merchants to spot ships at sea coming into harbour



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Galileo, the Astronomer

- Eventually, Galileo turned the telescope on the heavens to see if they would look different.
- To his amazement, they did, and he saw many things he could not see before.

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The Starry Messenger

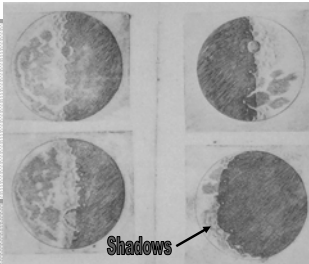
- In 1610, Galileo wrote and published a short pamphlet called *Siderius Nuncius* (*The Starry Messenger*) in which he reported his amazing findings.

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Mountains on the Moon

- Galileo found that the Moon was not a smooth, perfect sphere, but had an uneven surface.
- Mountains as large as the largest on Earth (that Galileo knew of).
- Determined by measuring shadows cast when the Sun shone at different angles.

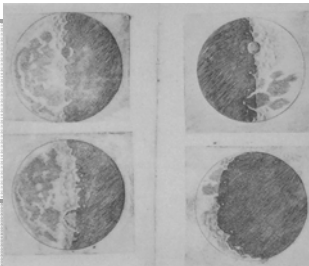


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Earthshine

- Galileo found that with a telescope he could make out some features on the dark side of the moon, which was lit by light reflected from the Earth.



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The Medicean "Stars"

▪ After repeated nights of observing Jupiter, Galileo noticed that there were four "stars" that appeared to circle round it.

▪ These he called, in honour of the Duke of Tuscany, "Medicean Stars."

▪ They were satellites of Jupiter, showing that the Earth was not the only planet with a "Moon."

	East	West
▪ Jan. 7, 1610	* * *	O * *
▪ Jan. 8		O * * *
▪ Jan. 10	* * *	O
▪ Jan. 11	* * *	O
▪ Jan. 12	* * *	O *
▪ Jan. 13	* * *	O * * *
▪ Feb. 26 early	* * *	O *
▪ Feb. 26 later	* * *	O *
▪ Feb. 27	* * *	O * * *
▪ Feb. 28	* * *	O *
▪ Feb. 28 later	* * *	O *
▪ March 1	* * * *	O

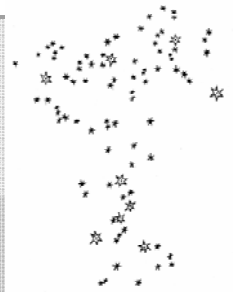
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Many More Stars

▪ Galileo saw that the "Milky Way" was not just a smear in the sky, but huge clusters of stars.

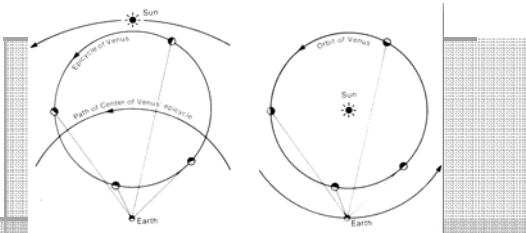
▪ The familiar constellations were surrounded by many stars not visible without the telescope. (Right: Orion's belt and sword as seen by Galileo.)



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The Phases of Venus



▪ Copernican theory implied that Venus should show phases, like the Moon. They were not visible with the naked eye.
 ▪ Galileo could see them with the telescope.

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Sun spots

- In a later work, Galileo reported that he could see spots on the Sun.
- Also, the Sun rotated, just like the Earth (in the Copernican theory).
- Galileo had become a committed Copernican.

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Evidence for Copernicus' theory from the telescope

- Instead of the heavenly bodies being perfect, smooth, and spherical and able to reflect light, while the Earth is rough and uneven, Galileo showed that the moon has a rough surface and the Earth reflects light onto the Moon. Even the Sun has blemishes and turns, like the Earth.
- The Earth is not the only planet with a satellite.
- There is much more to the heavens than can be seen without a telescope, suggesting the heavens are vast (as Copernicus stated).
- The phases of Venus provide visible confirmation for Copernicus.

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Galileo takes another job

- The fame that came to Galileo from *The Starry Messenger* enabled him to move from the University of Padua to a full-time research position.
- Galileo accepted an offer to become the Imperial Mathematician to the Duke of Tuscany in Florence in 1610.
 - No teaching, just research.

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Galileo, the Anti-anti-Copernican

- Galileo, armed with evidence from the telescope, took on the Scholastic Philosophers, who defended Aristotle and Ptolemy dogmatically.
- Galileo, a devout Catholic, began to *undermine Aristotle* at the privileged interpreter of the Bible.

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Letter to the Grand Duchess Christina

- 1615
- The Bible uses *figurative language*
 - Joshua commanding the Sun to stand still—merely a convenient expression.
 - Anyway, literally, Joshua should have commanded the celestial sphere to stop turning.
- Galileo objected to taking quotations out of the Bible, out of context, and believing them to be statements about the natural world.

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Galileo instructed not to “hold or defend” the Copernican view

- This was the Counter-Reformation.
 - The Catholic Church was most concerned about the Protestant threat to Papal authority.
 - No allowance for different points of view.
- In 1616, Galileo was enjoined *not* to hold or defend the view that the Earth moves and is not in the centre of the world.
 - Galileo interpreted this as meaning that he was not to say that Copernicus is *correct*.

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Dialogue Concerning the Two Chief World Systems

- 1632
- Platonic style dialogue
- Explanation of the *Tides*, from Copernican and Ptolemaic viewpoints
- --Three characters:
 - Salviati = the Copernican
 - Sagredo = impartial
 - Simplicio = Aristotelian



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The Dialogue, 2

- *Dialogue* systematically refutes every tenet of Aristotelian cosmology.
 - Simplicio's trump card played on the last page: God can do what He wants.
- Galileo called before *Inquisition*.
- 1633, condemned to life imprisonment for vehement suspicion of heresy.

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