

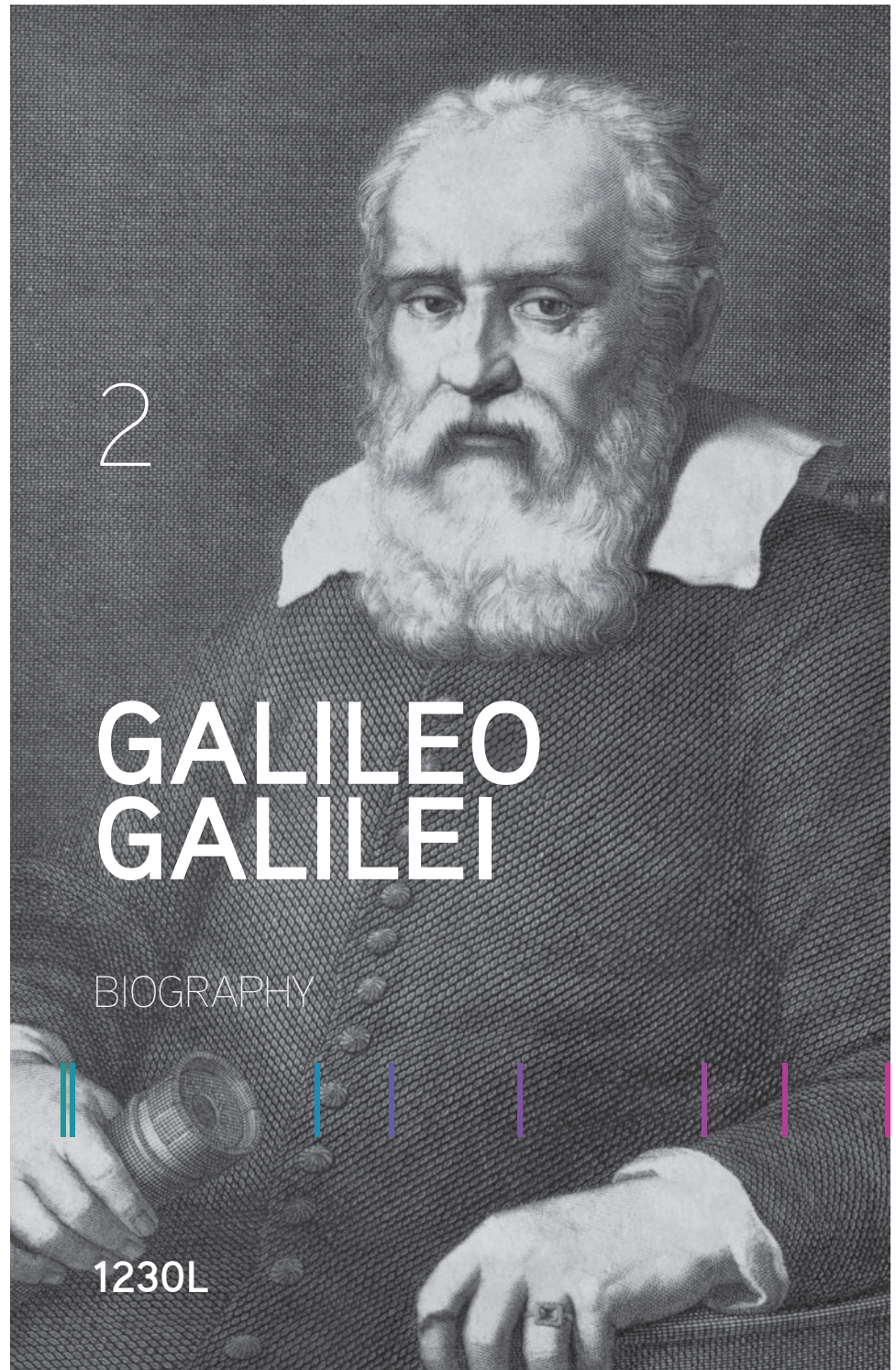
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GALILEO GALILEI

BIOGRAPHY

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GALILEO GALILEI

THE FATHER OF MODERN
OBSERVATIONAL ASTRONOMY

By Cynthia Stokes Brown

Born
February 15, 1564
Pisa, Italy

Died
January 9, 1642
Florence, Italy

An Italian Renaissance man, Galileo used a telescope of his own invention to collect evidence that supported a Sun-centered model of the Solar System.

Galileo Galilei was born in Pisa, Italy, on February 15, 1564, the first of seven children of Vincenzo Galilei and Giulia Ammanati. Galileo's father was a musician — a lute player — from a noble background.

When Galileo was 10, his family moved to Florence, northeast of Rome, where he was educated in a monastery. He was attracted to the priesthood, but his father steered him to study medicine from 1581 to 1585 at the University of Pisa, 40 miles west of Florence on the coast, and very near Galileo's childhood home.

University studies at that time were based primarily on Aristotle's philosophy, but Galileo's acute observations caused him to question some of these accepted views. He noticed that hailstones of different sizes reached the ground simultaneously, contradicting Aristotle's rule that bodies fall with speeds proportional to their size. At this time, Galileo also sat in on lectures by a practical mathematician, apart from his university studies.

Professor at Pisa and Padua

After four years at university, Galileo gave private lessons in mathematics and wrote his first scientific paper, about how things float on water. In 1587, he got a position teaching mathematics at the University of Pisa, which paid him a very modest salary. Two years later, Galileo's father died, leaving Galileo responsible for the promised dowries of his two sisters. The next year he secured the chair of mathematics at the renowned University of Padua, and the new position paid three times as much. In addition to mathematics, Galileo gave private instruction in military architecture, fortification, surveying, and mechanics.

At the age of 31, Galileo showed his first interest in astronomy, while working to explain the cause of the tides. Padua was 20 miles inland from Venice, an important trading port on the Adriatic Sea. Astronomy was considered part of mathematics at the time, while cosmology was part of philosophy. Most scholars still held the views of Ptolemy, who followed Aristotle in thinking that all heavenly bodies revolve around Earth (a geocentric model). But other views were being considered, including that of Nicolaus Copernicus, who claimed that all bodies revolve around the Sun (a heliocentric model), and of Danish astronomer Tycho Brahe, who held that Earth was fixed but other planets are in orbit around the Sun.

In 1597, Galileo read a book by German astronomer Johannes Kepler, who was enthusiastically pro-Copernicus. Galileo wrote a letter to Kepler stating that he had long agreed with Copernicus, but that he had not dared to make his thoughts public because he was frightened that he would become, like Copernicus, "mocked and hooted by an infinite multitude." In the same year, Galileo invented a mechanical device for mathematical calculations. He had a craftsman make them, so that Galileo could sell them and give classes on how to use them.

Professors at Padua tended not to marry, and prominent families there did not view Galileo as a catch. Instead, Galileo established a lasting relationship with a non-noble woman 14 years younger, Marina Gamba, and had three children with her. He never married her, and she and the children lived separately, around the corner from him. When he later left Padua in 1610 to move to Florence, he put their two daughters in a convent as soon as possible, and he left his son, Vincenzo, in Padua in Marina's care.

Galileo's first known astronomical observation occurred in 1604, when a supernova (the explosive death of a high-mass star) was visible in the sky. Such an event clearly challenged Aristotle's claim that no change could ever take place in the heavens. From then on, observation and experimentation became the basis for Galileo's work. Galileo's prominence as a mathematician and scholar grew, and in the summer of 1605 he arranged to tutor Cosimo de Medici, the son of the Grand Duke of Tuscany.



An undated engraving of Galileo and his telescope

In July 1609, Galileo heard about a Dutch device for making distant objects look nearer. A friend who saw it described it to Galileo as having two lenses, one on each end of a 4-foot tube. Within about a month, Galileo had made an instrument three times as powerful as the Dutch device.

Galileo continued to work on his telescope, grinding his own lenses. By December 1609, he had seen for the first time the four largest moons orbiting around Jupiter, which contradicted Ptolemaic theory that Earth is the center of all orbiting bodies. Galileo published his findings in March 1610 as *The Starry Messenger*. The general public was excited, but most philosophers and astronomers declared it an optical illusion.

Mathematics at the court of Tuscany

Galileo was offered life tenure at the University of Padua, but Florence was his home, and he wanted freedom from teaching. So he took the job of court mathematician in Florence, where his former math student had become Cosimo II, the Grand Duke of Tuscany.

Soon after his arrival in Florence in September 1610, Galileo began his observations of Venus. Over time he discovered that the Moon-like phases of Venus demonstrated that the neighboring planet had an orbit independent of Earth. This showed conclusively that Venus circled the Sun, as Copernicus thought, not Earth, as Ptolemy thought. But it did not yet prove conclusively that Earth circled the Sun.

In 1613, Galileo published his *Letters on Sunspots*, based on his observations of the dark spots on the Sun that are caused by intense magnetic activity.

In an appendix, he noted that he agreed with Copernicus, mentioning the fact that he had seen eclipses of the satellites of Jupiter, further evidence that they orbited the planet. This is the only time that Galileo expressed in print his support of the Copernican model. Galileo had no definitive evidence that Copernicus was right, and he didn't claim that he did. Galileo's main pieces of evidence were the phases of Venus; the eclipses of Jupiter's moons; the existence of tides, which Galileo believed could only occur if the Earth moved; observable planetary speeds, and the distances of planets from the Sun.

Drama with the Inquisition

During the first part of the 16th century, the Catholic Church was facing the challenge of Protestants, who were breaking away from the Church over certain doctrines. By this time, there were printers in many European cities and ideas were spreading quickly, some of them in opposition to the Catholic Church and its beliefs. To combat all heresies, the Pope set up a system of tribunals, or courts, called the Inquisition.

In 1616, the year of Shakespeare's death, the authorities of the Inquisition in Rome decided to prohibit Copernicus's book, *On the Revolutions of the Celestial Spheres*, and any other books that argued in favor of a Copernican Sun-centered model for the Solar System. Galileo traveled to Rome to try to prevent this; he thought it was a mistake that would eventually tarnish the Church's reputation. He believed that the Catholic Church should keep science and religion completely separate and not interfere with scientific research. The Church upheld its position, and Galileo agreed to obey the ban.

In 1623, a Florentine who admired Galileo became Pope Urban VIII. Galileo had six audiences (meetings) with the Pope in 1624 and received permission to publish his theory on the causes of tides, provided he did not take sides on the cosmological debate. For the next six years, Galileo worked on this book, which turned into a dialogue concerning the relative merits of the Ptolemaic and the Copernican conceptions of the Universe, without reaching a conclusion of one over the other. To carry out the discussion, Galileo invented three characters: Salviati, who gave Copernicus's views; Simplicio, who presented Aristotelian/Ptolemaic views; and Sagredo, an interested layman. Simplicio was named for an ancient Greek commentator on Aristotle. The title in English was *Dialogue Concerning the Two Chief World Systems — Ptolemaic and Copernican*.

The publisher of the book received a license to print, and the book appeared in Florence in March 1632. An outbreak of the plague delayed copies being sent to Rome. In August of the same year, an order came from the Roman Inquisition to stop all sales.

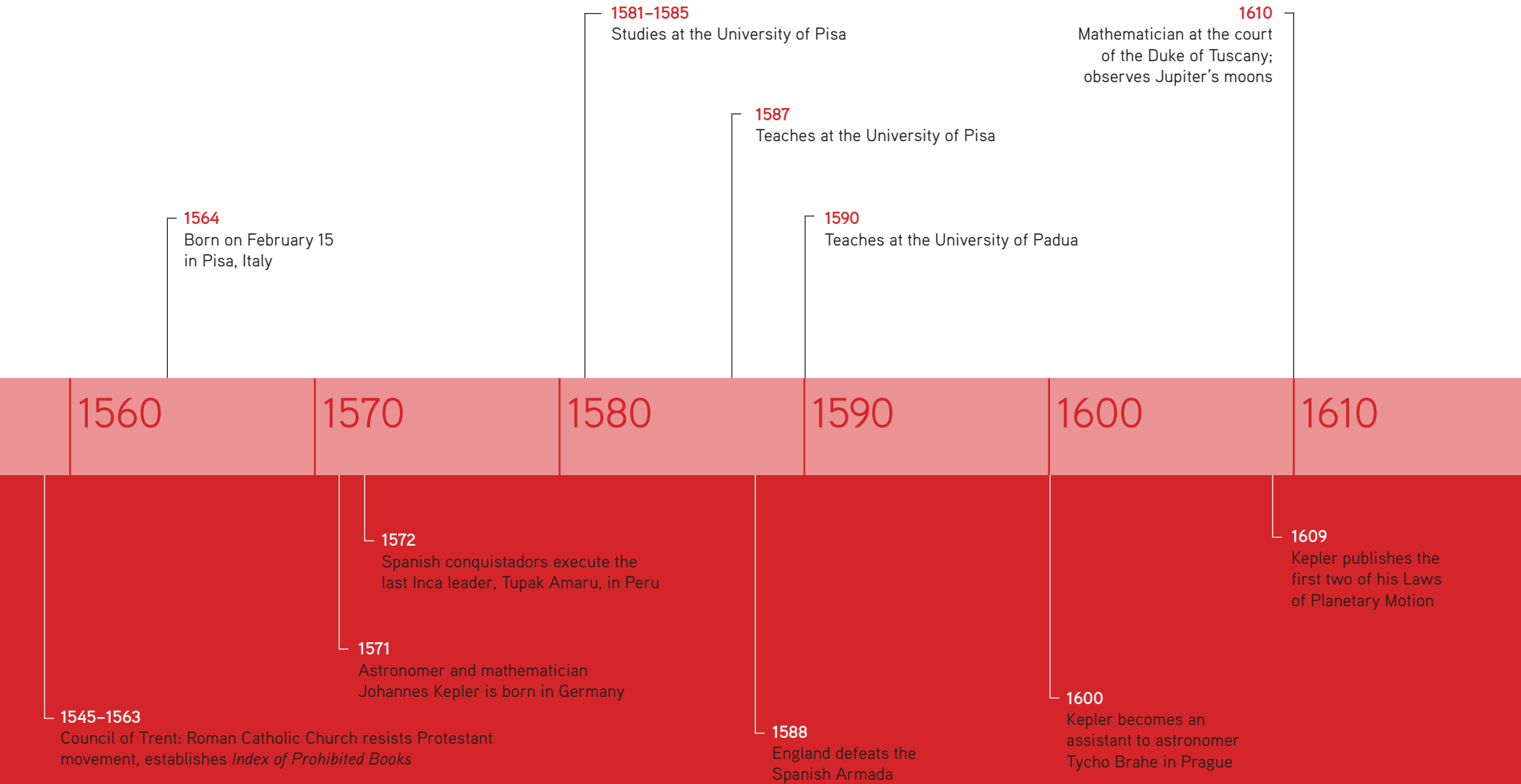
Galileo's student and friend, the Grand Duke Cosimo II, had died in 1621. The new Grand Duke of Tuscany, Ferdinand, protested the book, which seemed to him, and to many of the Church leaders, to portray Simplicio as a simpleton and fool, and thus to take sides in the debate. The Pope considered the character of Simplicio an insult, as did the other Church leaders. In September 1632, Galileo was charged with "vehement suspicion of heresy" and ordered to come to Rome for a trial. Ill, he did not appear until February 1633.

Galileo denied that he was defending heliocentrism, but he finally admitted that one could get that impression from the book. He was threatened with torture, forced to recant the heliocentric model, and, in June of that year, sentenced to indefinite imprisonment in Rome. His book was put on the Index of Prohibited Books. Three of the 10 judges disagreed with the verdict. Legend has it that as Galileo left the courtroom he whispered, "Eppur si muove [Still it (Earth) moves]," but this was most likely invented later.

Galileo was crushed by the harsh verdict. The archbishop of Siena, who had disagreed with the verdict, got permission to take Galileo into his home and helped him through his depression. Two years before his trial, Galileo had taken a villa on the outskirts of Florence, to be next to the convent where his daughters were nuns. After a few months in Rome, Galileo received permission to return to his own villa, to be guarded by representatives of the Inquisition, a house arrest. He was ill with a hernia, heart palpitations, and insomnia. A few months after his return home, his older daughter, Maria Celeste, with whom he was very close, died in April 1634.

The following year Galileo's book, *Dialogue Concerning the Two Chief World Systems — Ptolemaic and Copernican*, was published in Latin in Strasburg, Alsace (France), outside the grasp of the Catholic Inquisition, thereby reaching a much more cosmopolitan audience than the suppressed Italian text.

Timeline of Galileo's life



During the time of Galileo

Blindness and a legacy of truth

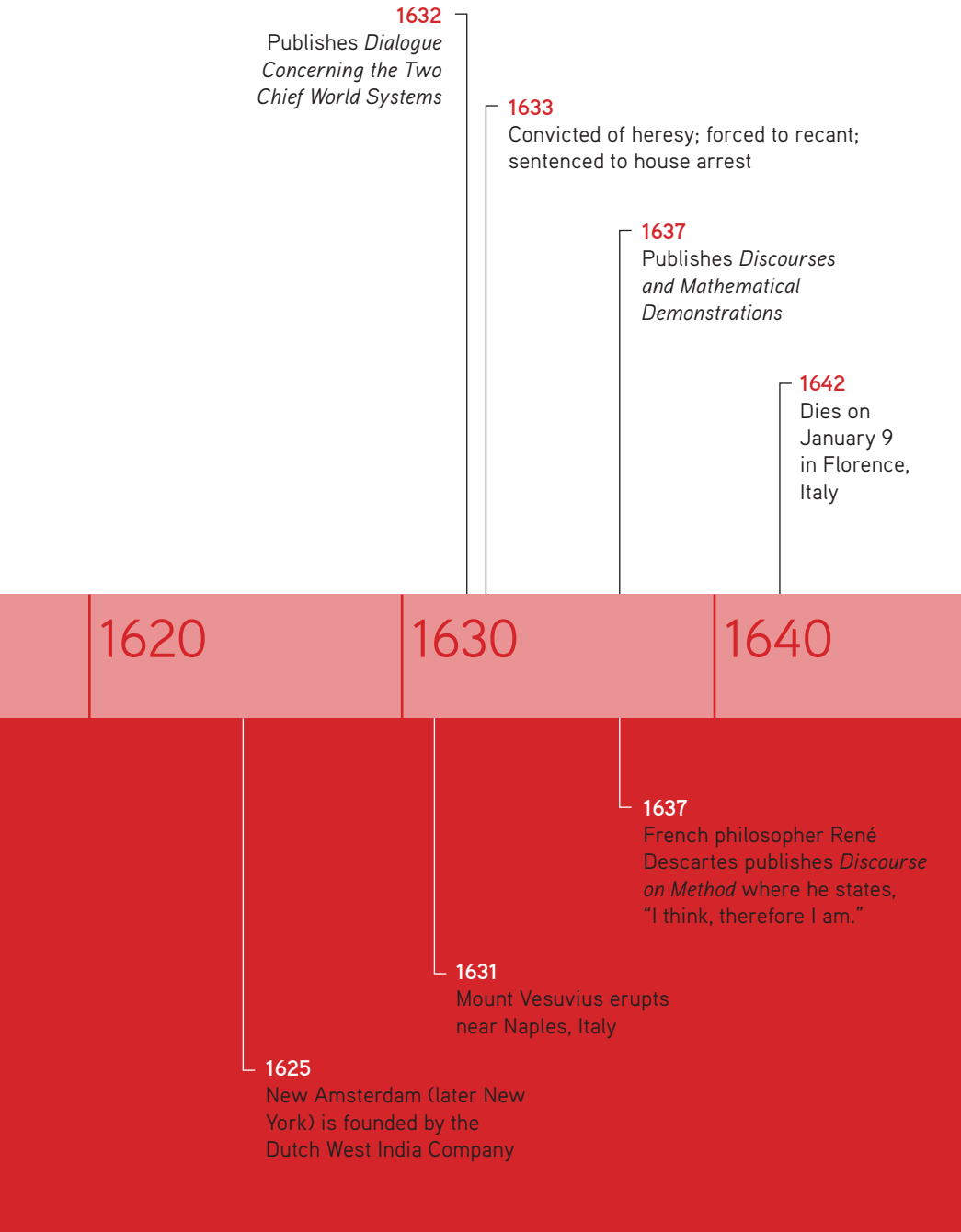
Galileo rallied and in his last years wrote a book summarizing all his ideas, published in 1637 in Holland in Italian. This book was translated into English in 1661 as *Discourses and Mathematical Demonstrations Relating to Two New Sciences*, and Isaac Newton read it in 1666.

By 1638, Galileo had become totally blind. He was allowed to live with his son in Florence and have visitors as long as they were not mathematicians. He carried on a great deal of correspondences by dictating his letters to others. He died on January 9, 1642, in Florence, at the age of 77. He was not allowed to be buried in the main body of the Basilica of Santa Croce, but in a small room at the end of a corridor; he was reburied in the main part in 1737.

The Catholic Church took 200 years to remove Galileo's book from the Index of Prohibited Books, finally doing so in 1835. In 1992, Pope John Paul II expressed regret at how the Church had handled Galileo and issued a declaration acknowledging the errors committed by the court of the Catholic Church. In 2008, plans were announced for a statue of Galileo inside the Vatican walls, but in 2009 these plans were suspended.

Galileo's own words to a friend about his blindness serve as a suitable epitaph:

Alas, your friend and servant Galileo has for the last month been irremediably blind, so that this heaven, this Earth, this Universe which I, by my remarkable discoveries and clear demonstrations had enlarged a hundred times beyond what had been believed by wise men of past ages, for me is from this time forth shrunk into so small a space as to be filled by my own sensations. (Drake, p. 107)



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An engraving of Galileo with his telescope
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