The beginning of modern physics

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Renaissance Genius: Galileo Galilei and His Legacy to Modern Science, David Whitehouse, Sterling, 2009 (US $24.95)

This volume is a welcome contribution to the study of the Italian Renaissance, written by the British archeologist David Whitehouse. It gives a comprehensive view of the world of the Italian Renaissance at a time when ideas, discoveries and new inventions accelerated the clash of science with the medieval institution of the Roman Catholic Church. The book's primary focus is the life and work of Galileo Galilei (1564-1642), whose persecution by the Church reflects the tribulations of most of the progressive thinkers of the time.

The book was published to coincide with the 400th anniversary of the year when Galileo turned his significantly improved version of the telescope to the night skies and began to draw the phases of the moon. It is lavishly illustrated with paintings, photographs, and illustrations that depict the time in which Galileo lived, his life, friends, colleagues, adversaries and persecutors.

As *Renaissance Genius* shows, this was the time of the Inquisition and its imprisonment, torture, and heinous executions of those deemed “heretics.” This included anyone who challenged existing church doctrine, particularly those developing the new techniques of observation, experimentation and the combination of the two with mathematics. Among those persecuted were Giordano Bruno, Antonio de Dominis and Galileo himself.

Vincenzo Galilei, Galileo's father, was a mathematician and music theorist who challenged traditional beliefs in the infallibility of Greek philosophic thought backed by both church and state. He found, for example, that the practical application of experimentation disproved long-held beliefs of the ancient Greek philosopher Pythagoras on musical interval and pitch between two strings. Pythagoras had held that in the tuning of strings, the weights used to stretch the strings, the tension must be doubled. It turned out that in practice, the tension had to be quadrupled, not doubled, to produce a tone an octave higher. As Whitehouse explains:

“It is hard to underestimate the importance of this moment in Galileo's life. He and his father had found a new harmony; a new set of mathematical laws that correlated the note produced by a string to its tension, and had done so by experiment. They had not looked up the answer in either an ancient Greek treatise nor sought the advice of some musical authority. This was the start of modern science: They had carried out an experiment and asked a question of nature itself. It was revolutionary. Vincenzo's actions had unfolded the course of his son's life in experimental physics.”

Later in life, Galileo would use experimental techniques to show that objects fall towards the Earth at the same rate, regardless of mass. That some objects seem to fall slower is because of air resistance, not a property of the objects themselves. This challenged the Aristotelian principle that claimed that heavier objects fall faster than lighter ones. The most famous of these experiments was done at the Leaning Tower of Pisa, when he released two identically shaped spheres of different masses from the top of the tower. The spheres, one of 100 pounds and the other only one pound, hit the ground at the same time.

Nearly 400 years later, astronaut David Scott of Apollo 15, carried out a similar experiment on the surface of the moon, releasing a feather and a metal hammer. Both struck the lunar surface at the same time. 'Galileo was correct,' exclaimed Scott.

Galileo's achievements also involve a number of inventions related to other fields of science. He developed the thermoscope, the predecessor of the thermometer, which was the first attempt to measure heat. The Venetian Senate awarded him a patent for a water-lifting machine used in irrigation that only used one horse. A friend in the tool-making trades helped Galileo develop a simple compass that could be used to gauge the distance and height of a target as well as measure the angle of elevation of a cannon's barrel. While Galileo did not invent the telescope, which was first built in the Netherlands in 1608, he is credited with increasing the magnification by 20 to 30 times using advanced lens-crafting techniques.

His interest in telescopes was sparked in 1604 when a new “star” appeared in the constellation Ophiuchus. This followed an earlier appearance of a new star in 1572 that was studied by the Danish astronomer Tycho Brahe. Such occurrences challenged the long-held notion of both the Aristotelians and the Church that the heavens are perfect and unchanging. Always being one to pursue observations, Galileo sought a way to study the night sky in greater detail.

With his telescope, he began to paint the different phases of the moon and its observable dark and light spots. He showed the moon to his patron, the Duke of Tuscany, who was delighted. Galileo then observed the Pleiades star cluster, as well as the planet Jupiter. Through these observations, he discovered the four largest moons of Jupiter - Io, Callisto, Europa and Ganymede, and provided the first evidence of objects orbiting a body other than the Earth. This was the proof Galileo needed to become a fervent advocate of the Copernican model of the cosmos.

A similar realization was made during Galileo's study of the phases of Venus, repeating in much greater detail observations done by Copernicus. After recording the pattern of sunlight reflected from Venus' atmosphere, he realized that the only way such patterns could occur is if both Venus and Earth revolved around the Sun. Galileo published a book on his observations, which circulated throughout Europe.

Included in his observations were the recording of sunspots. By aiming the telescope at the Sun and letting the light pass through the telescope onto a white background, Galileo was able to sketch out the positions of sunspots and determine that such imperfections on the Sun both existed and changed with time. Both this observation and the experimental evidence that the Earth is not the center of the universe incurred the wrath of the Church.

Both the Greek philosopher Aristotle and the Vatican considered the sun a perfect and unblemished sphere. The stars themselves were seen as divinities, contributing to the growth of astrology. It was argued by church supporters that the observed sunspots must be satellites of the sun and not 'imperfections' in its surface. Galileo stated that not only were sunspots on the surface of the sun, they changed their shapes, and both originated and dissolved on that sphere. This could only lead to one conclusion: the sun was not a perfect sphere.

Galileo's popularity and a newly established science academy in Rome ensured the continued publication of his works and a certain defense against the Church and other professional enemies. However, the issue of sunspots became the spark for an open clerical attack upon Galileo.

The story of how this debate unfolded is but one example of how the church and its privileged office-holders used the Bible to defame scientists like Galileo. Galileo himself believed that nothing that was discovered in any way conflicted with Scripture and quoted an ecclesiastical historian, Cardinal Baronius (1538-1607), who had commented: 'The Holy Ghost intended to teach us how to go to heaven, not how the heavens go.' This clever riposte did not save him. As Whitehouse points out:

"In his innate conservatism, Cardinal Bellarmine saw the Copernican universe as threatening to the social order. To him and to much of the Church's upper echelon, the science of the matter was beyond their understanding -- and in many cases their interest. They cared more for the administration and the preservation of Papal power than they did for getting astronomical facts right."

In the end, Galileo was told by Bellarmine and the head of the Inquisition, Cardinal Agostino Oreggi, that Copernicus' views were wrong and he was not to support them. Furthermore, he was ordered not to teach or defend Copernican theory in any way, either in his writings or verbally.

After Bellarmine and Pope Paul V died, Galileo still harbored great hopes that the new Pope, Urban VIII, his former friend Maffeo Barberini, would prove when elected to be much better than his predecessors. This was an illusion. He was summoned before an even more hostile Inquisition than the first time.

While Whitehouse speculates that for Barberini, being Pope "had gone to his head," the more fundamental truth is, as he observed earlier, that the Church hierarchy as a whole viewed "the Copernican universe as threatening to the social order." The Pope, no matter his individual origins, was bound by his place in medieval society to defend the status quo.

The reproductions in Whitehouse's book of paintings and illustrations depicting book burnings, the burnings at the stake for heresy, and the humiliations endured by thousands at the hands of the Inquisition reinforce this point.

Renaissance Genius depicts how Galileo's defense of the Copernican system and the subsequent discoveries by Kepler, Rene Descartes, and Isaac Newton not only established the beginnings of physics, but also led to the advances for science that have resulted in the modern space program, including the space probe named after Galileo and the Hubble space telescope, the most extraordinary advance in the technology which Galileo pioneered.

Whitehouse sums up the Galilean revolution by providing us with a very human portrait of the man, the history of his times and Galileo's indispensable role in the advancement and popularization of science for humankind.