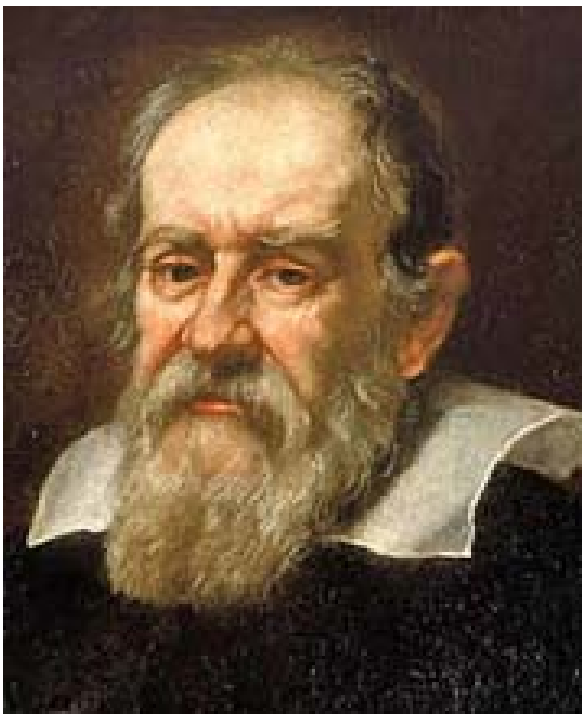


Galileo Galilei (1564 – 1642)

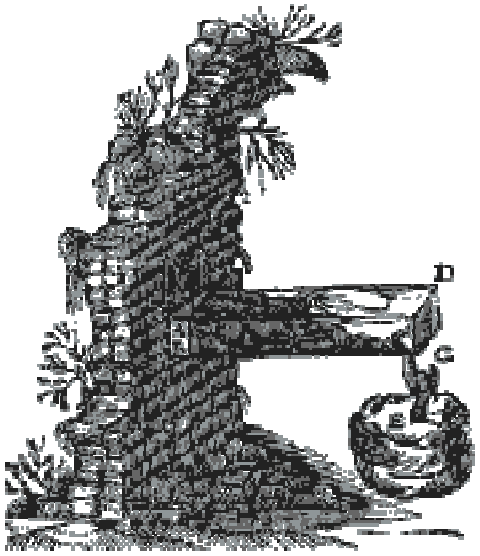
From Wikipedia, the free encyclopedia,
http://en.wikipedia.org/wiki/Galileo_Galilei

Galileo Galilei was an Italian physicist, mathematician, astronomer, and philosopher who played a major role in the Scientific Revolution. His achievements include improvements to the telescope and consequent astronomical observations and support for Copernicanism. Galileo has been called the "father of modern observational astronomy", the "father of modern physics", the "father of science", and "the Father of Modern Science".

His contributions to observational astronomy include the telescopic confirmation of the phases of Venus, the discovery of the four largest satellites of Jupiter (named the Galilean moons in his honour), and the observation and analysis of sunspots. Galileo also worked in applied science and technology, inventing an improved military compass and other instruments.

Galileo's championing of heliocentrism was controversial within his lifetime, when most subscribed to either geocentrism or the Tychonic system. He met with opposition from astronomers, who doubted heliocentrism due to the absence of an observed stellar parallax. The matter was investigated by the Roman Inquisition in 1615, and they concluded that it could only be supported as a possibility, not as an established fact. Galileo later defended his views in Dialogue Concerning the Two Chief World Systems, which appeared to attack Pope Urban VIII and thus alienated him and the Jesuits, who had both supported Galileo up until this point. He was tried by the Inquisition, found "vehemently suspect of heresy", forced to recant, and spent the rest of his life under house arrest. It was while Galileo was under house arrest that he wrote one of his finest works, Two New Sciences. Here he summarized the work he had done some forty years earlier, on the two sciences now called

kinematics and strength of materials.



Galileo was born in Pisa (then part of the Duchy of Florence), Italy, the first of six children of Vincenzo Galilei, a famous lutenist, composer, and music theorist, and Giulia Ammannati. Gaileo became an accomplished lutist himself and would have learned early from his father a healthy skepticism for established authority, the value of well-measured or quantified experimentation, an appreciation for a periodic or musical measure of time or rhythm, as well as the illuminative progeny to expect from a marriage of mathematics and experiment. Three of Galileo's five siblings survived infancy, and the youngest Michelangelo (or Michelagnolo) also became a noted lutenist and composer, although he contributed to financial burdens during Galileo's young adulthood. Michelangelo was incapable of contributing his fair share for their father's promised dowry's to their brothers-in-law, who would later attempt to seek legal remedies for payments due. Michelangelo would also occasionally have to borrow funds from Galileo for support of his musical endeavors and excursions. These financial burdens may have contributed to Galileo's early fire to develop inventions that would bring him additional income.

Galileo was named after an ancestor, Galileo Bonaiuti, a physician, university teacher and politician who lived in Florence from 1370 to 1450; at that time in the late 14th century, the family's surname shifted from Bonaiuti (or Buonaiuti) to Galilei. Galileo Bonaiuti was buried in the same church, the Basilica of Santa Croce in Florence, where about 200 years later his more famous descendant Galileo Galilei was buried too. When Galileo Galilei was 8, his family moved to Florence, but he was left with Jacopo Borghini for two years. He then was educated in the Camaldolese Monastery at Vallombrosa, 35 km southeast of Florence.

Although a genuinely pious Roman Catholic, Galileo fathered three children out of wedlock with Marina Gamba. They had two daughters, Virginia in 1600 and Livia in 1601, and one son, Vincenzo, in 1606. Because of their illegitimate birth, their father considered the girls unmarriageable, if not posing problems of prohibitively expensive support or dowry's, which would have been similar to Galileo's previous extensive financial problems with two of his sisters. Their only worthy alternative was the religious life. Both girls were sent to the convent of San Matteo in Arcetri and remained there for the rest of their lives. Virginia took the name Maria Celeste upon entering the convent. She died on 2 April 1634, and is buried with Galileo at the Basilica of Santa Croce, Florence. Livia took the name Sister Arcangela and was ill for most of her life.

Vincenzo was later legitimized as the legal heir of Galileo, and married Sestilia Bocchineri.

Although he seriously considered the priesthood as a young man, at his father's urging he instead enrolled at the University of Pisa for a medical degree. In 1581, when he was studying medicine, he noticed a swinging chandelier, which air currents shifted about to swing in larger and smaller arcs. It seemed, by comparison with his heartbeat, that the chandelier took the same amount of time to swing back and forth, no matter how far it was swinging. When he returned home, he set up two pendulums of equal length and swung one with a large sweep and the other with a small sweep and found that they kept time together. It was not until Christiaan Huygens almost one hundred years later, however, that the resonant nature of a swinging pendulum was used to create an accurate timepiece. To this point, he had deliberately been kept away from mathematics (since a physician earned so much more than a mathematician) but upon accidentally attending a lecture on geometry, he talked his reluctant father into letting him study mathematics and science instead. He created a grossly inaccurate thermoscope (now commonly referred to as a Galileo thermometer) in an attempt to measure temperature and in 1586 published a small book on the design of a hydrostatic balance he had invented (which first brought him to the attention of the scholarly world).

“Galileo was always making himself unpopular with influential people, for he had a brilliant and caustic wit and he could not resist using that wit to make jackasses -- and therefore bitter enemies -- of those who disagreed with him. Even as a college student, he had been nicknamed "the wrangler" because of his argumentativeness.”- Isaac Asimov

Galileo also studied disegno, a term encompassing fine art, and in 1588 attained an instructor position in the Accademia delle Arti del Disegno in Florence, teaching perspective and chiaroscuro. Being inspired by the artistic tradition of the city and the works of the Renaissance artists, Galileo acquired an aesthetic mentality. While a young teacher at the Accademia, he began a lifelong friendship with the Florentine painter Cigoli, who included Galileo's lunar observations in one of his paintings.

In 1589, he was appointed to the chair of mathematics in Pisa. In 1591 his father died and he was entrusted with the care of his younger brother Michelagnolo. In 1592, he moved to the University of Padua, teaching geometry, mechanics, and astronomy until 1610. During this period Galileo made significant discoveries in both pure fundamental science (for example, kinematics of motion and astronomy) as well as practical applied science (for example, strength of materials and improvement of the telescope). His multiple interests included the study of astrology, which at the time was a discipline tied to the studies of mathematics and astronomy.

Galileo made original contributions to the science of motion through an innovative combination of experiment and mathematics. More typical of science at the time were the qualitative studies of William Gilbert, on magnetism and electricity. Galileo's father, Vincenzo Galilei, a lutenist and music theorist, had performed experiments establishing perhaps the oldest known non-linear relation in physics: for a stretched string, the pitch varies as the square root of the tension. These observations lay within the framework of the Pythagorean tradition of music, well-known to instrument makers, which included the fact that subdividing a string by a whole number produces a harmonious scale. Thus, a limited amount of mathematics had long related music and physical science, and young Galileo could see his own father's observations expand on that tradition.

Galileo was one of the first modern thinkers to clearly state that the laws of nature are mathematical. In The Assayer he wrote "Philosophy is written in this grand book, the universe ... It is written in the language of mathematics, and its characters are triangles, circles, and other geometric figures;...." His mathematical analyses

are a further development of a tradition employed by late scholastic natural philosophers, which Galileo learned when he studied philosophy. He displayed a peculiar ability to ignore established authorities, most notably Aristotelianism. In broader terms, his work marked another step towards the eventual separation of science from both philosophy and religion; a major development in human thought. He was often willing to change his views in accordance with observation. In order to perform his experiments, Galileo had to set up standards of length and time, so that measurements made on different days and in different laboratories could be compared in a reproducible fashion. This provided a reliable foundation on which to confirm mathematical laws using inductive reasoning.

Galileo showed a remarkably modern appreciation for the proper relationship between mathematics, theoretical physics, and experimental physics. He understood the parabola, both in terms of conic sections and in terms of the ordinate (y) varying as the square of the abscissa (x). Galilei further asserted that the parabola was the theoretically ideal trajectory of a uniformly accelerated projectile in the absence of friction and other disturbances. He conceded that there are limits to the validity of this theory, noting on theoretical grounds that a projectile trajectory of a size comparable to that of the Earth could not possibly be a parabola, but he nevertheless maintained that for distances up to the range of the artillery of his day, the deviation of a projectile's trajectory from a parabola would only be very slight.

Galileo made a number of contributions to what is now known as technology, as distinct from pure physics. This is not the same distinction as made by Aristotle, who would have considered all Galileo's physics as techne or useful knowledge, as opposed to episteme, or philosophical investigation into the causes of things. Between 1595 and 1598, Galileo devised and improved a Geometric and Military Compass suitable for use by gunners and surveyors. This expanded on earlier instruments designed by NiccolòTartaglia and Guidobaldo del Monte. For gunners, it offered, in addition to a new and safer way of elevating cannons accurately, a way of quickly computing the charge of gunpowder for cannonballs of different sizes and materials. As a geometric instrument, it enabled the construction of any regular polygon, computation of the area of any polygon or circular sector, and a variety of other calculations. Under Galileo's direction, instrument maker Marc'Antonio Mazzoleni produced more than 100 of these compasses, which Galileo sold (along with an instruction manual he wrote) for 50 lire and offered a course of instruction in the use of the compasses for 120 lire.

In about 1593, Galileo constructed a thermometer, using the expansion and contraction of air in a bulb to move water in an attached tube.

A replica of the earliest surviving telescope attributed to Galileo Galilei, on display at the Griffith Observatory. In 1609 Galileo was, along with Englishman Thomas Harriot and others, among the first to use a refracting telescope as an instrument to observe stars, planets or moons. The name "telescope" was coined for Galileo's instrument by a Greek mathematician, Giovanni Demisiani, at a banquet held in 1611 by Prince Federico Cesi to make Galileo a member of his Accademia dei Lincei. The name was derived from the Greek tele = 'far' and skopein = 'to look or see'. In 1610, he used a telescope at close range to magnify the parts of insects. By 1624 Galileo had perfected a compound microscope. He gave one of these instruments to Cardinal Zollern in May of that year for presentation to the Duke of Bavaria, and in September he sent another to Prince Cesi. The Linceans played a role again in naming the "microscope" a year later when fellow academy member Giovanni Faber coined the word for Galileo's invention from the Greek words micron meaning "small", and skopein meaning "to look at". The word was meant to be analogous with "telescope". Illustrations of insects made using one of Galileo's microscopes, and published in 1625, appear to have been the first clear documentation of the use of a compound microscope.

In 1612, having determined the orbital periods of Jupiter's satellites, Galileo proposed that with sufficiently accurate knowledge of their orbits one could use their positions as a universal clock, and this would make possible the determination of longitude. He worked on this problem from time to time during the remainder of his life; but the practical problems were severe. The method was first successfully applied by Giovanni Domenico Cassini in 1681 and was later used extensively for large land surveys; this method, for example, was used by Lewis and Clark. For sea navigation, where delicate telescopic observations were more difficult, the longitude problem eventually required development of a practical portable marine chronometer, such as that of John Harrison. In his last year, when totally blind, he designed an escapement mechanism for a pendulum clock (called Galileo's escapement. The first fully operational pendulum clock was made by Christiaan Huygens in the 1650s.

On 31 October 1992, Pope John Paul II expressed regret for how the Galileo affair was handled, and issued a declaration acknowledging the errors committed by the Catholic Church tribunal that judged the scientific positions of Galileo Galilei, as the result of a study conducted by the Pontifical Council for Culture. In March 2008 the head of the Pontifical Academy of Sciences, Nicola Cabibbo, announced a plan to honour Galileo by erecting a statue of him inside the Vatican walls. In December of the same year, during events to mark the 400th anniversary of Galileo's earliest telescopic observations, Pope Benedict XVI praised his contributions to astronomy.

According to Stephen Hawking, Galileo probably bears more of the responsibility for the birth of modern science than anybody else, and Albert Einstein called him the father of modern science.

Galileo's astronomical discoveries and investigations into the Copernican theory have led to a lasting legacy which includes the categorisation of the four large moons of Jupiter discovered by Galileo (Io, Europa, Ganymede and Callisto) as the Galilean moons. Other scientific endeavours and principles are named after Galileo including the Galileo spacecraft, the first spacecraft to enter orbit around Jupiter, the proposed Galileo global satellite navigation system, the transformation between inertial systems in classical mechanics denoted Galilean transformation and the Gal (unit), sometimes known as the Galileo which is a non-SI unit of acceleration.

Partly because 2009 was the fourth centenary of Galileo's first recorded astronomical observations with the telescope, the United Nations scheduled it to be the International Year of Astronomy. A global scheme was laid out by the International Astronomical Union (IAU), also endorsed by UNESCO—the UN body responsible for Educational, Scientific and Cultural matters. The International Year of Astronomy 2009 was intended to be a global celebration of astronomy and its contributions to society and culture, stimulating worldwide interest not only in astronomy but science in general, with a particular slant towards young people.

Asteroid 697 Galilea is named in his honour.