MEN AND MEDICINE

• GALILEO GALILEI

In 1581, a seventeen year old youth, a native of the town, began his studies at the University of Pisa, hoping in time to become a physician. He was small in stature, lively in actions and in speech, with features described as agreeable rather than handsome. He possessed a natural eloquence and a beguiling manner so that those with whom he talked were charmed and converted rather than always intellectually persuaded to share his beliefs. His family was an old and respected one, of the minor Florentine nobility. His father was a cloth merchant, an amateur musician of some talent and repute and nearly as well known for his pugnacity.

In preparation for the medical career, the young student sat in on discourses and lectures in which the professors expounded on and explained the classical masters, particularly Galen and Aristotle. To the teachings of these authorities, this young man took frequent and vocal exceptions; he disputed the facts with his professors and argued against their conclusions. He became more interested in mathematics somewhere during his course-work; he gave up medicine as his intended career and concentrated his studies on numbers. Perhaps he already believed that "science was measurement" and "nature spoke in numbers." While still a student, he observed that each swing of the pendulum took an equal time. At age 19 he had foreseen the pendulum clock and at age 22 he developed a hydrostatic balance with which specific gravity could be measured. Such talents could not go unrecognized, and at 25 Galileo Galilei was appointed professor of mathematics at Pisa.

The new professor was a typical man of the Renaissance which was then in progress. He knew poetry and art and music as well as his chosen profession. His memory was prodigious and he knew by heart most of Virgil, Ovid, Horace and Seneca, among the ancients, much of Petrarch and nearly all of the tragedy of Ariosto. He wrote plentifully and his writings were quite as easy, natural and fluent as his speech. When the occasion demanded he could argue brilliantly and with great polemic skill, not sometimes without the use of sarcasm which left his opponents demolished, embittered and angry.

The liveliness of Galileo, in his speech and writings as in his actions, seems in many ways the counterpart of the great intellectual activity of the Renaissance, the ferment which had the intellectual world moving and seething. This was compounded of many elements. The earlier renaissances had been marked by the recovery of the ancient knowledge of Greece and Rome, which had been lost for centuries. This new knowledge was spread over Europe by the increasing number of printing presses so that even by 1500 the works of Aristotle had appeared in 95 editions, Avicenna in 14 editions and the *Regimen* of Salerno in 41 editions. Luther's 95 theses nailed to the church door in Wittenburg in 1517 had questioned the authority and even the authenticity of the great universal Catholic Church. Vesalius had published in 1543 his epoch-making *De Fabrica* contradicting the anatomy of the great Galen and recalling the doctors to the study of the human body as the logical basis for theory and practice. In the same year had appeared Copernicus' *De Orbe*, suggesting that the sun was the center of the universe and not the world as the teachings of Aristotle and Ptolemy had held, and as was the currently and universally prevalent teaching.

The explorations of the Italians and Spaniards and those of the Portuguese and English were opening up a New World, expanding the physical horizons of man in much the same way that the rediscovered and widely distributed classics, the printing press and the dissent of Luther, Vesalius and Copernicus were enlarging in his intellectual ones. The Middle Ages just past had seen improvements in the production, handling and distribution of foodstuffs; its recurrent plagues had decreased the population enough to give new value to the individual. Commerce was expanding with the opening of new trade routes and the reopening of old ones. New sources of power for manufacture were available in the wind mills and water mills. Although we do not know precisely what brought into being the great Renaissance into which Galileo was

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born we can recognize the appearance of many conditions favorable to intellectual and artistic activity and we can see their results in the works of many great men, one of the greatest of whom was Galileo.

Galileo was born in Pisa, February 14, 1564. This must have been one of the most important years in human history. In it both Michelangelo and Vesalius died and both Shakespeare and Christopher Marlowe were born, in addition to Galileo. It would be impossible to detail the events of Galileo's life and still keep this article within reasonable size. Many useful and agreeable books recount this; among these I would recommend particularly de Santillana's *The Crime of Galileo* (University of Chicago Press, 1955). The present article will only sketch his life and try to explain his importance for modern science and modern medicine.

It has already been mentioned that Galileo's studies had included the works of Aristotle. This universal genius, living from 384 to 322 B.C., had taken all knowledge for his province. His philosophy in fragments had kept alive the light of learning in Europe through the centuries and the rediscovery of the main body of his works had initiated earlier renaissances. Incorporated into the doctrines of the Church by Thomas Aquinas, his doctrines had taken on the weight of dogma. It was not only in philosophy that Aristotle was pre-eminent and the "Master of those who know," as Dante called him, was the authority also in biology, in physics and mechanics and in cosmogony, or the world view. His biology, great as it was, does not concern us here. Concerning motion, Aristotle taught that the natural state of bodies was at rest. Some materials fell to the center of the earth, earth and water for examples, because they possessed *gravity*. Others fled from the earth because they possessed *levity*, fire and air for examples. All bodies were made up of these four elements of earth, air, fire and water in various proportions. Bodies were kept in motion only by the continuing action of the mover. The universe in Aristotle's teaching consisted of the earth in the center of a series of concentric crystalline and transparent spheres on which the stars, the moon and the sun were arranged. The rotation of these spheres determined day and night and the passage of the seasons. These summary statements give only an imperfect idea of Aristotle's concepts which Galileo was to overthrow, setting the stage for the progress of the Renaissance.

Galileo began his assault on Aristotelian Mechanics while still a student, and only 21 years of age, with a systematic investigation of their concepts. The results were a "Treatise on Motion" in 1592 and "Discourses on Two New Sciences" in 1638. In these and in lesser studies in between, but including the great "The Assayer" in 1624, Galileo overthrew the main Aristotelian ideas on motion and substituted the ideas of impetus, acceleration, and a number of others which form the basis for our modern science. Even more important perhaps, he emphasized the necessity of quantitation in science and put it on a firm and permanent footing.

The contradiction of Aristotle's mechanics made Galileo suspect and unpopular with the great majority of his traditionally-minded and unquestioning colleagues. It was, however, Galileo's espousal of the Copernican hypothesis that led to his greatest breach with the authorities. A primitive telescope was constructed in 1609 to his specifications, and in 1610 Galileo published a little book of 24 pages, *The Messenger of the Stars,* describing the moon with geographic features like another earth, masses of stars in the nebulae and the milky way and Jupiter and its satellites, almost like another universe. In 1612 Galileo saw the sunspots and decided that the universe was not static, stable, and unchanging as the traditional teaching had it. He taught by this time that the Copernicus theory of a heliocentric universe was true and the classical geocentric view was false. This brought him into conflict with the Church, and in 1616 he had to agree to refrain from such teachings. However, in 1630 he brought forth with ecclesiastical approval the "Dialogue on Two World Systems" in which the proponents of the Copernican and the Aristotelian-Ptolemaic theories debated the merits of their viewpoints. Simplicius the Aristotelian had the worst of the argument and moreover closely resembled one of the leaders in the Church. After a denunciation and

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Fever of Undetermined Origin in Children by John H. A. Bomberger, M.D. (Radio Conference)

Adrenocortical Function Tests—A Re-evaluation of the Urinary 17-Ketosteroids by Norman H. Ertel, M.D.

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hearing before the Inquisition, nominally for teaching that which had been forbidden, Galileo went into retirement in 1633. By this time he was blind in one eye and the sight in the other was failing; he was partially deaf and suffering from painful limbs which made movement difficult. Galileo Galilei died in Arcebi on January 8, 1642, the year of Newton's birth.

Galileo's conflict with the authorities concerning the new Copernican heliocentric theory of the universe and the classical Ptolemaic geocentric theory had the right on Galileo's side but the wrong arguments. In the Copernican theory the spheres of the classical theory were maintained, increased in number to 34 to accommodate the moon, the earth and all the planets in their courses. These did not explain the phenomena, or "save the appearances" in the older term, as adequately as the Ptolemaic theory deriving from Plato, Eudoxus and Aristotle with the epicycles and pericycles added over the centuries. It was not until Kepler proposed elliptical motions for the moon, earth and stars, that the astronomical data could be used by Newton to produce the mathematical universe superior to the Ptolemaic concept, and conceived in modern terms.

In this conflict between science and religious authority, Galileo made a great contribution in demarcating areas of competence. Discussing the bad effects which might result from use of authority without proper information Galileo said:

> It is as if an absolute ruler should demand, without being either a physician or an architect, that people should treat themselves or build buildings, according to his directions, to the great jeopardy of the poor patients and the manifest ruination of the edifices.

It is unfortunate that this confrontation between the Church and Galileo occurred at all, especially since Thomas Aquinas had emphasized the tentative nature of the Ptolemaic theory, which could be replaced when a better was found, and since St. Augustine long ago had said:

> We should not hold rashly an opinion in a scientific matter, so that we may not come to hate later whatever truth may reveal to us, out of love for our own error.

The ultimate proof of the correctness of Galileo's viewpoint did much to weaken the influence of organized religion in scientific affairs. It is worth noting that Martin Luther spoke of "that fool Copernicus" and John Donne would have hailed him before the Judge of Hell, along with Paracelsus and Machiavelli.

What were Galileo's greatest accomplishments? To begin with he overthrew the classical Aristotelian mechanics and helped in the defeat of the Ptolemaic-Aristotelian world theory. In these he completed the overthrow of classical authority, breaking these intellectual fetters, and allowing the mind of man to range freely in the search for the truth. In emphasizing mathematics and measurement Galileo set men on the examination of phenomena rather than attempting to "explain" them; he substituted the question "how" for the question "why" and so laid the foundation for our scientific world of today. In demonstrating that the observable universe, the world, the stars, and the bodies on the world, were subject to mathematical and logical analysis, Galileo set the course for the search for the "mastery of nature" which is the aim of scientific investigation, as Bacon says. Lesser contributions of Galileo were the telescope, the microscope, the thermometer, which he either invented or popularized, as well as the pendulum clock and the hydrostatic balance. Further, Galileo's writings were in the vernacular as if he foresaw the influence, for the future, of his thoughts and observations and wished to place them directly before the people whose lives they were to alter so greatly.

After Galileo the Renaissance could progress into the Scientific Revolution and in time into the Industrial Revolution and eventually to the Scientific Information Explosion of today. Man was shown that authority was to be questioned and contradicted, that the world and all in it could be measured and mathematically considered, that man could understand and control the physical world. As the father of modern science Galileo Galilei must be considered likewise as a father of scientific medicine in the present era.

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