Galileo Galilei

Generally called GALILEO. Born at Pisa, 15 February, 1564; died 8 January, 1642.

His father, Vincenzo Galilei, belonged to a noble family of straitened fortune, and had gained some distinction as a musician and mathematician. The boy at an early age manifested his aptitude for mathematical and mechanical pursuits, but his parents, wishing to turn him aside from studies which promised no substantial return, destined him for the medical profession. But all was in vain, and at an early age the youth had to be left to follow the bent of his native genius, which speedily placed him in the very first rank of natural philosophers.

It is the great merit of Galileo that, happily combining experiment with calculation, he opposed the prevailing system according to which, instead of going directly to nature for investigation of her laws and processes, it was held that these were best learned by authority, especially by that of Aristotle, who was supposed to have spoken the last word upon all such matters, and upon whom many erroneous conclusions had been fathered in the course of time. Against such a superstition Galileo resolutely and vehemently set himself, with the result that he not only soon discredited many beliefs which had hitherto been accepted as indisputable, but aroused a storm of opposition and indignation amongst those whose opinions he discredited; the more so, as he was a fierce controversialist, who, not content with refuting adversaries, was bent upon confounding them. Moreover, he wielded an exceedingly able pen, and unsparingly ridiculed and exasperated his opponents. Undoubtedly he thus did much to bring upon himself the troubles for which he is now chiefly remembered. As Sir David Brewster (Martyrs of Science) says, "The boldness, may we not say the recklessness, with which Galileo insisted on making proselytes of his enemies, served but to alienate them from the truth."

Although in the popular mind Galileo is remembered chiefly as an astronomer, it was not in this character that he made really substantial contributions to human knowledge — as is testified by such authorities as Lagrange, Arago, and Delambre — but rather in the field of mechanics, and especially of dynamics, which science may be said to owe its existence to him.

Before he was twenty, observation of the oscillations of a swinging lamp in the cathedral of Pisa led him to the discovery of the isochronism of the pendulum, which theory he utilized fifty years later in the construction of an astronomical clock. In 1588, a treatise on the centre of gravity in solids obtained for him the title of the Archimedes of his time, and secured him a lecture-ship in the University of Pisa. During the years immediately following, taking advantage of the celebrated leaning tower, he laid the foundation experimentally of the theory of falling bodies and demonstrated the falsity of the peripatetic maxim, hitherto accepted without question, that their rate of descent is proportional to their weight. This at once raised a storm on the part of the Aristoteleans, who would not accept even facts in contradiction of their master's dicta.

Galileo, in consequence of this and other troubles, found it prudent to quit Pisa and betake himself to Florence, the original home of his family. By the influence of friends with the Venetian Senate he was nominated in 1592 to the chair of mathematics in the University of Padua, which he occupied for eighteen years, with ever-increasing renown. He afterwards betook himself to Florence, being appointed philosopher and mathematician extraordinary to the Grand Duke of Tuscany. During the whole of this period, and to the close of his life, his investigation of Nature, in all her fields, was unwearied. Following up his experiments at Pisa with others upon inclined planes, Galileo established the laws of falling bodies as they are still formulated. He likewise demonstrated the laws of projectiles, and largely anticipated the laws of motion as finally established by Newton. He studied the properties

of the cycloid and attempted the problem of its quadrature; while in the "infinitesimals", which he was one of the first to introduce into geometrical demonstrations, was contained the germ of the calculus. In statics, he gave the first direct and entirely satisfactory demonstration of the laws of equilibrium and the principle of virtual velocities. In hydrostatics, he set forth the true principle of flotation. He invented a thermometer (termometro lento), though a defective one, but he did not, as is sometimes claimed for him, invent the microscope.

Though, as has been said, it is by his astronomical discoveries that he is most widely remembered, it is not these that constitute his most substantial title to fame. In this connection, his greatest achievement was undoubtedly his virtual invention of the telescope. Hearing early in 1609 that a Dutch optician, named Lippershey, had produced an instrument by which the apparent size of remote objects was magnified, Galileo at once realized the principle by which such a result could alone be attained, and, after a single night devoted to consideration of the laws of refraction, he succeeded in constructing a telescope which magnified three times, its magnifying power being soon increased to thirty-two. This instrument being provided and turned towards the heavens, the discoveries, which have made Galileo famous, were bound at once to follow, though undoubtedly he was quick to grasp their full significance. The moon was shown not to be, as the old astronomy taught, a smooth and perfect sphere, of different nature to the earth, but to possess hills and valleys and other features resembling those of our own globe. The planet Jupiter was found to have satellites, thus displaying a solar system in miniature, and supporting the doctrine of Copernicus. It had been argued against the said system that, if it were true, the inferior planets, Venus and Mercury, between the earth and the sun, should in the course of their revolution exhibit phases like those of the moon, and, these being invisible to the naked eye, Copernicus had to advance the quite erroneous explanation that these planets were transparent and the sun's rays passed through them. But with his telescope Galileo found that Venus did actually exhibit the desired phases, and the objection was thus turned into an argument for Copernicanism. Finally, the spots on the sun, which Galileo soon perceived, served to prove the rotation of that luminary, and that it was not incorruptible as had been assumed.

Prior to these discoveries, Galileo had already abandoned the old Ptolemaic astronomy for the Copernican. But, as he confessed in a letter to Kepler in 1597, he had refrained from making himself its advocate, lest like Copernicus himself he should be overwhelmed with ridicule. His telescopic discoveries, the significance of which he immediately perceived, induced him at once to lay aside all reserve and come forward as the avowed and strenuous champion of Copernicanism, and, appealing as these discoveries did to the evidence of sensible phenomena, they not only did more than anything else to recommend the new system to general acceptance, but invested Galileo himself with the credit of being the greatest astronomer of his age, if not the greatest who ever lived. They were also the cause of his lamentable controversy with ecclesiastical authority, which raises questions of graver import than any others connected with his name. It is necessary, therefore, to understand clearly his exact position in this regard.

The direct services which Galileo rendered to astronomy are virtually summed up in his telescopic discoveries, which, brilliant and important as they were, contributed little or nothing to the theoretical perfection of the science, and were sure to be made by any careful observer provided with a telescope. Again, he wholly neglected discoveries far more fundamental than his own, made by his great contemporary Kepler, the value of which he either did not perceive or entirely ignored. Since the first and second of his famous laws were already published by Kepler in 1609 and the third, ten years later, it is truly inconceivable, as Delambre says, that Galileo should not once have made any mention of these discoveries, far more difficult than his own, which finally led Newton to determine the general principle which forms the very soul of the celestial mechanism thus established. It is, moreover,

undeniable, that the proofs which Galileo adduced in support of the heliocentric system of Copernicus, as against the geocentric of Ptolemy and the ancients, were far from conclusive, and failed to convince such men as Tycho Brahé (who, however, did not live to see the telescope) and Lord Bacon, who to the end remained an unbeliever. Milton also, who visited Galileo in his old age (1638), appears to have suspended his judgment, for there are passages in his great poem which seem to favour both systems. The proof from the phenomenon of the tides, to which Galileo appealed to establish the rotation of the earth on its axis, is now universally recognized as a grave error, and he treated with scorn Kepler's suggestion, foreshadowing Newton's establishment of the true doctrine, that a certain occult influence of the moon was in some way responsible. In regard to comets, again, he maintained no less erroneously that they were atmospheric phenomena, like meteors, though Tycho had demonstrated the falsity of such a view, which was recommended only as the solution of an anti-Copernican difficulty.

In spite of all deficiency in his arguments, Galileo, profoundly assured of the truth of his cause, set himself with his habitual vehemence to convince others, and so contributed in no small degree to create the troubles which greatly embittered the latter part of his life.

In regard to their history, there are two main points to be considered. It is in the first place constantly assumed, especially at the present day, that the opposition which Copernicanism encountered at the hands of ecclesiastical authority was prompted by hatred of science and a desire to keep the minds of men in the darkness of ignorance. To suppose that any body of men could deliberately adopt such a course is ridiculous, especially a body which, with whatever defects of method, had for so long been the only one which concerned itself with science at all.

It is likewise contradicted by the history of the very controversy with which we are now concerned. According to a popular notion the point, upon which beyond all others churchmen were determined to insist, was the geocentric system of astronomy. Nevertheless it was a churchman, Nicholas Copernicus, who first advanced the contrary doctrine that the sun and not the earth is the centre of our system, round which our planet revolves, rotating on its own axis. His great work, "De Revolutionibus orbium coelestium", was published at the earnest solicitation of two distinguished churchmen, Cardinal Schömberg and Tiedemann Giese, Bishop of Culm. It was dedicated by permission to Pope Paul III in order, as Copernicus explained, that it might be thus protected from the attacks which it was sure to encounter on the part of the "mathematicians" (i.e. philosophers) for its apparent contradiction of the evidence of our senses, and even of common sense. He added that he made no account of objections which might be brought by ignorant wiseacres on Scriptural grounds. Indeed, for nearly three quarters of a century no such difficulties were raised on the Catholic side, although Luther and Melanchthon condemned the work of Copernicus in unmeasured terms. Neither Paul III, nor any of the nine popes who followed him, nor the Roman Congregations raised any alarm, and, as has been seen, Galileo himself in 1597, speaking of the risks he might run by an advocacy of Copernicanism, mentioned ridicule only and said nothing of persecution. Even when he had made his famous discoveries, no change occurred in this respect. On the contrary, coming to Rome in 1611, he was received in triumph; all the world, clerical and lay, flocked to see him, and, setting up his telescope in the Quirinal Garden belonging to Cardinal Bandim, he exhibited the sunspots and other objects to an admiring throng.

It was not until four years later that trouble arose, the ecclesiastical authorities taking alarm at the persistence with which Galileo proclaimed the truth of the Copernican doctrine. That their opposition was grounded, as is constantly assumed, upon a fear lest men should be enlightened by the diffusion of scientific truth, it is obviously absurd to maintain. On the contrary, they were firmly convinced, with Bacon and others, that the new teaching was radically false and unscientific, while it is now truly admitted that Galileo himself had no sufficient proof of what he so vehemently advocated, and

Professor Huxley after examining the case avowed his opinion that the opponents of Galileo "had rather the best of it". But what, more than all, raised alarm was anxiety for the credit of Holy Scripture, the letter of which was then universally believed to be the supreme authority in matters of science, as in all others. When therefore it spoke of the sun staying his course at the prayer of Joshua, or the earth as being ever immovable, it was assumed that the doctrine of Copernicus and Galileo was anti-Scriptural; and therefore heretical. It is evident that, since the days of Copernicus himself, the Reformation controversy had done much to attach suspicion to novel interpretations of the Bible, which was not lessened by the endeavours of Galileo and his ally Foscarini to find positive arguments for Copernicanism in the inspired volume. Foscarini, a Carmelite friar of noble lineage, who had twice ruled Calabria as provincial, and had considerable reputation as a preacher and theologian, threw himself with more zeal than discretion into the controversy, as when he sought to find an argument for Copernicanism in the seven-branched candlestick of the Old Law. Above all, he excited alarm by publishing works on the subject in the vernacular, and thus spreading the new doctrine, which was startling even for the learned, amongst the masses who were incapable of forming any sound judgment concerning it. There was at the time an active sceptical party in Italy, which aimed at the overthrow of all religion, and, as Sir David Brewster acknowledges (Martyrs of Science), there is no doubt that this party lent Galileo all its support.

In these circumstances, Galileo, hearing that some had denounced his doctrine as anti-Scriptural, presented himself at Rome in December, 1615, and was courteously received. He was presently interrogated before the Inquisition, which after consultation declared the system he upheld to be scientifically false, and anti-Scriptural or heretical, and that he must renounce it. This he obediently did, promising to teach it no more. Then followed a decree of the Congregation of the Index dated 5 March 1616, prohibiting various heretical works to which were added any advocating the Copernican system. In this decree no mention is made of Galileo, or of any of his works. Neither is the name of the pope introduced, though there is no doubt that he fully approved the decision, having presided at the session of the Inquisition, wherein the matter was discussed and decided. In thus acting, it is undeniable that the ecclesiastical authorities committed a grave and deplorable error, and sanctioned an altogether false principle as to the proper use of Scripture. Galileo and Foscarini rightly urged that the Bible is intended to teach men to go to heaven, not how the heavens go. At the same time, it must not be forgotten that, while there was as yet no sufficient proof of the Copernican system, no objection was made to its being taught as an hypothesis which explained all phenomena in a simpler manner than the Ptolemaic, and might for all practical purposes be adopted by astronomers. What was objected to was the assertion that Copernicanism was in fact true, "which appears to contradict Scripture". It is clear, moreover, that the authors of the judgment themselves did not consider it to be absolutely final and irreversible, for Cardinal Bellarmine, the most influential member of the Sacred College, writing to Foscarini, after urging that he and Galileo should be content to show that their system explains all celestial phenomena — an unexceptional proposition, and one sufficient for all practical purposes — but should not categorically assert what seemed to contradict the Bible, thus continued:

I say that if a real proof be found that the sun is fixed and does not revolve round the earth, but the earth round the sun, then it will be necessary, very carefully, to proceed to the explanation of the passages of Scripture which appear to be contrary, and we should rather say that we have misunderstood these than pronounce that to be false which is demonstrated.

By this decree the work of Copernicus was for the first time prohibited, as well as the "Epitome" of Kepler, but in each instance only donec corrigatur, the corrections prescribed being such as were necessary to exhibit the Copernican system as an hypothesis, not as an established fact. We learn

further that with permission these works might be read in their entirety, by "the learned and skilful in the science" (Remus to Kepler). Galileo seems, says von Gebler, to have treated the decree of the Inquisition pretty coolly, speaking with satisfaction of the trifling changes prescribed in the work of Copernicus. He left Rome, however, with the evident intention of violating the promise extracted from him, and, while he pursued unmolested his searches in other branches of science, he lost no opportunity of manifesting his contempt for the astronomical system which he had promised to embrace. Nevertheless, when in 1624 he again visited Rome, he met with what is rightly described as "a noble and generous reception". The pope now reigning, Urban VIII, had, as Cardinal Barberini, been his friend and had opposed his condemnation in 1616. He conferred on his visitor a pension, to which as a foreigner in Rome Galileo had no claim, and which, says Brewster, must be regarded as an endowment of Science itself. But to Galileo's disappointment Urban would not annul the former judgment of the Inquisition.

After his return to Florence, Galileo set himself to compose the work which revived and aggravated all former animosities, namely a dialogue in which a Ptolemist is utterly routed and confounded by two Copernicans. This was published in 1632, and, being plainly inconsistent with his former promise, was taken by the Roman authorities as a direct challenge. He was therefore again cited before the Inquisition, and again failed to display the courage of his opinions, declaring that since his former trial in 1616 he had never held the Copernican theory. Such a declaration, naturally was not taken very seriously, and in spite of it he was condemned as "vehemently suspected of heresy" to incarceration at the pleasure of the tribunal and to recite the Seven Penitential Psalms once a week for three years.

Under the sentence of imprisonment Galileo remained till his death in 1642. It is, however, untrue to speak of him as in any proper sense a "prisoner". As his Protestant biographer, von Gebler, tells us, "One glance at the truest historical source for the famous trial, would convince any one that Galileo spent altogether twenty-two days in the buildings of the Holy Office (i.e. the Inquisition), and even then not in a prison cell with barred windows, but in the handsome and commodious apartment of an official of the Inquisition." For the rest, he was allowed to use as his places of confinement the houses of friends, always comfortable and usually luxurious. It is wholly untrue that he was — as is constantly stated — either tortured or blinded by his persecutors — though in 1637, five years before his death, he became totally blind — or that he was refused burial in consecrated ground. On the contrary, although the pope (Urban VIII) did not allow a monument to be erected over his tomb, he sent his special blessing to the dying man, who was interred not only in consecrated ground, but within the church of Santa Croce at Florence.

Finally, the famous "E pur si muove", supposed to have been uttered by Galileo, as he rose from his knees after renouncing the motion of the earth, is an acknowledged fiction, of which no mention can be found till more than a century after his death, which took place 8 January 1642, the year in which Newton was born.

Such in brief is the history of this famous conflict between ecclesiastical authority and science, to which special theological importance has been attached in connection with the question of papal infallibility. Can it be said that either Paul V or Urban VIII so committed himself to the doctrine of geocentricism as to impose it upon the Church as an article of faith, and so to teach as pope what is now acknowledged to be untrue? That both these pontiffs were convinced anti-Copernicans cannot be doubted, nor that they believed the Copernican system to be unscriptural and desired its suppression. The question is, however, whether either of them condemned the doctrine ex cathedra. This, it is clear, they never did. As to the decree of 1616, we have seen that it was issued by the Congregation of the Index, which can raise no difficulty in regard of infallibility, this tribunal being absolutely incompetent

to make a dogmatic decree. Nor is the case altered by the fact that the pope approved the Congregation's decision in forma communi, that is to say, to the extent needful for the purpose intended, namely to prohibit the circulation of writings which were judged harmful. The pope and his assessors may have been wrong in such a judgment, but this does not alter the character of the pronouncement, or convert it into a decree ex cathedra.

As to the second trial in 1633, this was concerned not so much with the doctrine as with the person of Galileo, and his manifest breach of contract in not abstaining from the active propaganda of Copernican doctrines. The sentence, passed upon him in consequence, clearly implied a condemnation of Copernicanism, but it made no formal decree on the subject, and did not receive the pope's signature. Nor is this only an opinion of theologians; it is corroborated by writers whom none will accuse of any bias in favour of the papacy. Thus Professor Augustus De Morgan (Budget of Paradoxes) declares

It is clear that the absurdity was the act of the Italian Inquisition, for the private and personal pleasure of the pope — who knew that the course he took could not convict him as pope — and not of the body which calls itself the Church.

And von Gebler ("Galileo Galilei"):

The Church never condemned it (the Copernican system) at all, for the Qualifiers of the Holy Office never mean the Church.

It may be added that Riceloll and other contemporaries of Galileo were permitted, after 1616, to declare that no anti-Copernican definition had issued from the supreme pontiff.

More vital at the present day is the question with which we commenced: "Does not the condemnation of Galileo prove the implacable opposition of the Church to scientific progress and enlightenment?" It may be replied with Cardinal Newman that this instance serves to prove the opposite, namely that the Church has not interfered with physical science, for Galileo's case "is the one stock argument" (Apologia 5). So too Professor De Morgan acknowledges ("Motion of the Earth" in English Cyclopaedia):

The Papal power must upon the whole have been moderately used in matters of philosophy, if we may judge by the great stress laid on this one case of Galileo. It is the standing proof that an authority which has lasted a thousand years was all the time occupied in checking the progress of thought.

So Dr. Whewell speaking of this same case says (History of the Inductive Sciences):--

I would not be understood to assert the condemnation of new doctrines to be a general or characteristic practice of the Romish Church. Certainly the intelligent and cultivated minds of Italy, and many of the most eminent of her ecclesiastics among them, have been the foremost in promoting and welcoming the progress of science, and there were found among the Italian ecclesiastics of Galileo's time many of the earliest and most enlightened adherents of the Copernican system.