GALILEO AND THE ROMAN INQUISITION

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TO MY DEAR FRIEND
MRS BYRON IVANCOVICH
WHO ENABLED ME TO SEE
THE MOONS OF JUPITER
AND
THE RINGS OF SATURN
* * *

Galileo and the Roman Inquisition

THE MAN

Galileo Galilei, of an old and distinguished Florentine family, was born at Pisa on 15 February 1564, and is the last of the great Italians, with the exception of ruling dynasties, to be known almost universally by his first or given name. His father, Vincenzio Galilei, a cloth merchant in a small way and wretchedly poor, was a highly accomplished musician, composer, and theorist of music, whose many books on those subjects revealed traits later to be found in his even more gifted son, a good knowledge of mathematics, distrust and contempt of reliance on authority in scientific matters, and an extremely pugnacious temper. From this difficult man Galileo acquired his lifelong love of music, with a particular addiction to the lute, which he composed for and played like a master. He also became highly skilled in drawing, and might well have developed into an artist of considerable attainment, had he given his mind to it. Though his published verses were undistinguished, he had certainly in him the soul of a major poet, as many passages of his prose works attest. Unfortunately, no one knew better than Galileo himself what an all-rounder he was in brilliance. He had many virtues, but modesty was not conspicuous among them. Indeed, a fervent modern admirer of our man, the well-known German writer on scientific subjects Rudolf Thiel, says of him candidly: 'By nature this great scientist and scholar was bellicose, passionate, spiteful, ruthlessly determined, and unscrupulous in his choice of methods'.

After failure at the age of twenty-three to obtain the chair of mathematics at Bologna, Galileo was obliged by his father to veer on a different tack. Vincenzio drew on his scanty resources to enrol him as a student of medicine at the University of Pisa, a profession that would at least keep the wolf from the door more surely than music, art, or mathematics, as the unsuccessful cloth vendor was bitterly aware. In medicine, Claudius Galen, who had flourished in the second century A.D., was quoted by Galileo's professors as the last word on the physical ailments of mankind. This preposterous deference to so ancient an authority roused all the devil in the young Florentine, who destroyed the peace of the lecture room by his constant interruptions with objections and counter-arguments. His conduct earned him the nickname of 'The Wrangler', and wrangle he did for the rest of his life. He soon renounced medicine

and its second century nostrums, and secured when only twenty-five the miserably paid chair of mathematics at the University of Pisa. In that post he sharpened his hatchet for an assault on much bigger game than Galen, none other than the portentous Aristotle himself, Dante's 'Master of Those who Know'.

ARISTOTLE'S ASTRONOMY

Galileo underestimated the genius of Aristotle, which was greater even than his own. Building on the mathematical analysis of planetary motion worked out a few years earlier by his contemporaries Eudoxus and Callippus, Aristotle constructed a physical system of the heavens which was very largely original. He postulated a stationary earth, the region of change, of generation and decay, with its corruptible elements of earth, water, air, and fire. Beyond this dust-bin of the universe lay the moon, the planets, and the fixed stars, all composed of a fifth element, a quintessence which rendered them immune from any change except motion in circles round the earth. The circles had come to be conceived as vast hollow, solid but invisible crystalline spheres, carrying in their rims the Moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn, and the fixed stars. Using first-class mathematical analysis, Aristotle found that fifty-five such spheres were required in order to give a physical and mathematical explanation of the apparent irregularity of the planetary paths, which he conceived to be compounded of four or five different circular motions. Though wrong in fact, as Galileo was so startlingly to prove, this theory did give plausible physical explanations of a wide range of celestial phenomena. Wise after the event, and with his telescope to assist, Galileo did not give Aristotle sufficient credit as a great pioneering astronomer, with nothing but his mathematics and his brilliant mind to help him.

Aristotle's theories were given further elaboration and improvement by two geniuses of the first rank, the Greek Hipparchus who flourished at Rhodes during the second century B.C., and the Egyptian Claudius Ptolemy who became illustrious at Alexandria during the second century A.D. Ptolemy's astronomical treatise, known by its Arabic title as the Almagest, is a complete exposition of the views and theories of Hipparchus, with improvements and extensions of detail by Ptolemy himself. From the information provided in the Almagest Hipparchus has come to be regarded by historians of the science as one of the greatest astronomers of all time. Ptolemy resurrected the ingenious Greek theory of epicycles and eccentrics to account for the non-circular motions of the planets, particularly Mars. The Almagest so effectively 'saved the appearances' of the heavens, helped navigation, and enabled eclipses to be predicted, that it became the astronomical Bible of the Western world for fourteen centuries, until the Pole, Canon Nicholas Copernicus, provided an alternative and much simpler explanation of the heavenly phenomena by postulating the movement of the earth around the sun in his great, largely mathematical, treatise On the Revolutions of the Celestial Orbs, published in 1543 with a dedication to Pope Paul III.

Owing to the magnificent synthesis of Christian doctrine which the genius of St Thomas Aquinas had constructed on the basis of Aristotle's metaphysical and other writings, the Stagyrite, as he is called from the place of his birth in Greece, gradually assumed an extraordinary dominance over the minds of men in every sphere of intellectual inquiry, and particularly in what would now be called the field of natural science. Aristotle had been pre-eminent in this field, and his work on biology, for instance, deeply impressed even such a master as Charles Darwin. But as a pioneer the great man inevitably made mistakes. By the sixteenth century, a highly authoritarian age, even his mistakes had become as it were canonized and turned into dogmas which to question was considered impious. Aristotle himself

would have been the first to scorn such an attitude, but there it was, and Galileo, who had so much in common with the splendid investigator of antiquity, reacted against it with all the vigour and violence at his command, thus doing true science an enormous service.

GALILEO'S FIRST ONSLAUGHT ON THE CONSERVATIVES

During his professorship at Pisa he was probably already a convinced Copernican in his astronomical views, but contented himself at the time with knocking the bottom out of a main Aristotelian dogma of his colleagues, namely, that the acceleration of falling bodies depended on their weight. One memorable day he paid a visit of devotion to Pisa Cathedral, where the sanctuary lamp had recently been filled and was swinging slowly to rest. He forgot his prayers as a thought suddenly struck him. The swings, whether long or short, seemed to take exactly the same time, which he proved in a rough and ready fashion by using his pulse beats as a chronometer. Now, as the downward swing of a pendulum could be regarded as a falling body, he became convinced that bodies, whatever their weight, accelerated in falling at the same pace. In a vacuum, which Galileo had not the means to produce, a ball of lead and a feather would reach the ground at the same time. It is said {in one legend} that to confirm his inspired guess the young Florentine experimenter climbed to the top of the Leaning Tower of Pisa and dropped a cannon ball and a bullet, finding to his delight that they reached the ground almost simultaneously.

His colleagues at Pisa deeply resented this attack on their cherished dogma, and made things so hot for Galileo that he deemed it expedient to quit his native Tuscany for the Republic of Venice, where he secured the long-vacant chair of mathematics at Venice's university in Padua. He remained at Padua for eighteen years, living most of the time in concubinage, regarded tolerantly in those days, with a Venetian woman named Marina Gamba, who bore him two daughters and a son. One of the pleasantest features of his extremely complex character was his devotion to those illegitimate children. He almost beggared himself on their behalf. The elder daughter in particular, who in due course took her vows as a nun in a convent close to Arcetri, near Florence, where her father had purchased a farm, became under her religious name of Suor Maria Celeste the confidante and supreme joy of Galileo's old age. Her letters to him have survived and are a sheer delight.

THE GREAT KEPLER COMES ON THE SCENE

In 1609, a year of destiny for Galileo, the German astronomer Johannes Kepler, a profoundly religious and endearing genius, in spite of his many foibles, published an enormous tome entitled Astronomia Nova. He was a pupil of the illustrious and wealthy Danish astronomer Tycho Brahe who, as a good Lutheran, had felt the Copernican theory to be contrary to the Scriptures and devised a system of his own according to which the planets circled round the sun, while the sun with its attendant planets circled round a stationary earth. This theory could be regarded as half-way stage to full Copernicanism and was adopted by many, particularly by the astronomers of the Society of Jesus who did not believe that Copernicus himself, nor Galileo later on, had proved the earth to be in motion. Blaise Pascal, the Jansenist and the Jesuit's deadliest foe, but a scientist of genius, found it impossible to choose between Tycho's theory and Copernicanism, as each equally well accounted for the heavenly phenomena.

After Tycho Brahe's death in 1601, Kepler, whose own Lutheranism had in no way deterred him from

becoming an ardent Copernican, acquired the Dane's incomparably accurate observations of the orbit of the strangely erratic planet Mars which had puzzled watchers of the skies ever since the times of the Chaldaeans and Babylonians. After the most painstaking analysis of Tycho's data over several years, Kepler arrived at his epoch-making discovery that the observations could be satisfactorily represented by the simple assumption that the earth and Mars both described ellipses about the sun as focus. Thus at a stroke the ancient Greek conception that the movements of the planets must be compounded of circular motions, together with the resultant complicated system of epicycles and eccentrics which had bedevilled astronomical theory for so long, were finally swept away.

GALILEO'S YEAR OF DESTINY AT PADUA

Kepler sent Galileo a copy of his huge book, but that busy genius ignored it and continued to hold to the end of his life the ancient Greek theory of circular motions in the heavens, in this putting himself into the company of the dunder-headed Aristotelians against whom he was always contending. In June or July of 1609, the year ironically enough when Kepler had disposed of 'circularity' in the heavens for ever, Galileo had heard of an optical instrument invented in Holland by which distant objects could be made to appear closer. He knew no details of the invention but soon figured them out for himself and set to work with furious energy to construct a whole series of 'spyglasses', as telescopes were first called, until he had one which magnified objects nearly a thousand times and brought them thirty times closer than when regarded by the naked eye. This instrument he turned on the clear Paduan night sky, with shattering results for the cosmology of Aristotle and Ptolemy, already seriously damaged by Tycho Brahe's observations of comets and the stars called novae, which proved that the theory of crystal spheres was completely untenable and that the heavens beyond the moon were as subject to change as the earth itself.

Galileo published his telescopic discoveries at Padua in March 1610, in a large-sized pamphlet which he dedicated in an extremely fulsome preface to Cosimo de' Medici, Grand Duke of Tuscany, whom as a boy he had coached in mathematics. He wrote in Latin as he wished the pamphlet to reach as quickly as possible astronomers and philosophers all over Europe. He called it the Sidereus Nuncius, meaning the messenger or the message of the stars. In the preface to it he declared quite openly that the sun, not the earth, was at the centre of the universe. The first object to which he turned his attention was the moon. The telescope revealed a vast number of smaller spots occurring all over the lunar surface, as distinguished from the larger spots visible to the naked eye. 'The smaller spots had never been seen by anyone before me. From the observation of these spots repeated many times, I have been led to the opinion and conviction that the surface of the moon is not smooth, uniform, and precisely spherical as a great number of philosophers believe it (and the other heavenly bodies) to be, but is uneven, rough, and full of cavities and prominences, being, not unlike the face of the earth, relieved by chains of mountains and deep valleys.' He then gives an account of the things he saw which forced him to draw his conclusions, and provides five admirable sketches of the moon, as well as diagrams to illustrate the points he was making. Having dealt with the moon and blown sky-high in the process 'a great number of philosophers', he goes on to say that in a later work 'we shall prove the earth to be a wandering body surpassing the moon in splendour, and not the sink of all dull refuse of the universe'.

When the matchless observer turned his telescope on the constellation of Orion, he counted more than five hundred new stars never seen before, distributed among the old ones visible to the naked eye, and the Pleiades instead of being just Seven Sisters proved to be a large family of more than forty stars. He illustrates with admirable diagrams eighty new stars adjacent to the six in the Sword and the three in

the Belt of Orion already known. His telescope revealed the Milky Way as 'nothing but a congeries of innumerable stars grouped together in clusters . . . many of them rather large and quite bright, while the number of small ones is altogether beyond calculation'. In the nebula of Praesepe in the constellation Cancer he counted a mass of more than forty small stars and in that called the Head of Orion twenty-one stars. But Galileo's most enthralling discovery is still to come, 'the disclosure of four planets never seen from the creation of the world up to our time'.

On the night of 7 January 1610 he was using the best telescope he had so far made for himself, and the planet Jupiter swam into his ken. He had often studied it before without any special interest, but this night he observed three very bright starlets beside the planet. He thought that they must belong to the host of fixed stars, but they aroused his curiosity by appearing to lie in an exact straight line parallel to the ecliptic and in being more splendid than other fixed stars of their size. Two of them lay to the east of Jupiter and one to the west. The following night, 8 January, he turned his telescope on Jupiter again and found to his astonishment that all there starlets were now on the west of the planet and closer together. He began to wonder whether Jupiter might not be moving to the east and so getting ahead of the starlets, though all the computations of the astronomers showed it to be apparently moving towards the west. He looked forward with lively interest to the next night, 9 January, to see what was happening to his starlets, but the sky was heavily over-cast and he had to wait impatiently for the following night. His perplexity was then transformed into amazement, for he found that two of the starlets, which he was certain were the same as those he had previously observed, now stood in a straight line to the east of Jupiter, while the third was missing altogether. He was then convinced that the apparent changes did not belong to Jupiter but to the observed stars. 'I resolved to pursue this investigation with greater care and attention', he writes. Night after freezing night he continued to watch until 2 March, ten days before the publication of his results. Sometimes he appears to have stayed up half the night, 'for the revolutions of these planets are so speedily completed that it is usually possible to take even their hourly variations'. On 13 January he saw four stars for the first time, one to the east and three in a humped shape to the west.

The starlets or satellites, to use the term provided by the ever-resourceful Kepler, seemed constantly to become larger or smaller with reference to their fellows and also to change their distance from Jupiter and from one another. On 26 February, Galileo wanted to observe the progress of Jupiter and his newly found family along the line of the zodiac in relation to some fixed star, and such a one he found, eleven minutes of an arc distant from the most easterly satellite. All his subsequent observations were made in relation to this fixed star.

GALILEO DECLARES OPENLY FOR COPERNICANISM

No other planetary satellite had been discovered at that time and some men who were disposed to accept the Copernican system had their faith in it disturbed by the fact that the earth alone of the orbs encircling the sun was privileged to possess a moon. 'Now', writes Galileo triumphantly, 'we have not just one planet rotating about another while both run through a great orbit around the sun; our own eyes show us four stars which wander around Jupiter as the moon does around the earth, while all together trace out a grand revolution about the sun in the space of twelve years.' The newly discovered moons of Jupiter he decided should be called the 'Medicean Stars' in honour of his sovereign, Cosimo de' Medici, Grand Duke of Tuscany. The Sidereus Nuncius contains beautifully drawn diagrams illustrating all the movements of those Medicean Stars. They made their discoverer a celebrity at once throughout Europe and even carried his name as far as Peking, where a Jesuit astronomer published the Starry Messenger

in Chinese only five years after its original appearance. Perhaps it may be added that Jupiter has a plethora of moons, as seven other smaller ones were discovered after Galileo's time, but this in no way detracts from his glory.

Why, we might wonder, did not the openly declared Copernicanism of the Starry Messenger disturb the more reputable theologians at the time of its publication? The reason appears to have been that the long dead Polish priest's treatise On the Revolutions of the Heavenly Orbs bore a reassuring preface in Latin which stated that 'the author of the book had done nothing deserving of reprehension, as it is the business of an astronomer to calculate the movements of the heavens by diligent and ingenious observation. Then he excogitates and invents various hypotheses to account for the movements so that by the principles of geometry they may be explained in the past and foretold in the future. But the real causes of the movements are utterly beyond his discovery. This is what the present writer brilliantly does, but it is not necessary that these hypotheses should be true to reality nor even plausible. It is enough if his calculations are seen to fit the observed movements'. As the writer of the preface speaks of the author of the book in the third person, it seems obvious that it was not Copernicus himself who wrote it, and Galileo trumpeted that fact loudly, though not he but Kepler discovered the forger's name and revealed it in a book of his which did not see the light until the nineteenth century.

The bogus preface was written by a very eminent Protestant theologian of Nuremberg where the book of Copernicus was printed under his direction. In the fashion of the time he had Graecized his name of Heiligmann into Osiander. He corresponded with Copernicus, of whom he was a warm admirer and in whose heliocentrism he firmly believed, but he did not ask his permission to write the preface nor submit it to him, knowing that it would be rejected out of hand, as Copernicus was convinced of the physical reality of heliocentrism. The preface was a piece of well-meant but misguided diplomacy. Osiander had quarrelled with Luther and his lieutenant Melanchthon over the question of justification, and knew that both men were determinedly opposed to heliocentrism on Scriptural grounds. By declaring that the theory was merely a mathematician's hypothesis, claiming no physical reality, he hoped to placate the two stalwarts and that thus Copernicus might be accorded a hearing in Germany as elsewhere. His preface had an enormous success, for it reassured both Catholics and Protestants, and poor Copernicus never knew of the trick that had been played on him, as he was dying when the first copy of the De Revolutionibus was brought to him in 1543.

After the publication of the Starry Messenger Galileo made two further discoveries, the first being the peculiar shape of the planet Saturn, which his telescope was not powerful enough to resolve into the famous rings, an honour that remained for the great Dutch scientist and astronomer Huygens thirteen years after his death. Galileo interpreted the strange shape of the planet as being due to the presence of two satellites, one on each side and almost touching Saturn. The shape remained unchanged for a long time and he gave up observing it for about three years, when lo and behold, he discovered that Saturn was without its supporting satellites 'and as perfectly round and sharply bounded as Jupiter'. He was completely puzzled and wondered whether indeed Saturn had devoured his children, as in the myth, or whether his telescope had deceived him and many others who had observed the phenomenon with him. However, he ventured to prophesy that after the winter solstice of 1614 the satellites would be seen again, and they were, but they were not satellites. Meantime, at his own urgent request and to the indignation of the Venetian authorities, Galileo abandoned his post at Padua to take up an official position as mathematician and philosopher to the Court of Tuscany.

Back in Florence he made his second and far more significant discovery, namely, that the planet Venus passes through a regular series of changes in shape, or phases, exactly resembling those of the moon. Copernicus had been distressed that he could not observe such phases, indiscernible to the naked eye,

as they were necessary to his heliocentric theory. Galileo now supplied the evidence which proved that Venus must be moving round the sun, and showed Ptolemy to be wrong in a very important part of his planetary theory.

The publication of those shattering discoveries caused great alarm and indignation in the Aristotelian camp. Some of the die-hard worthies gave Galileo the lie direct and maintained that the discoveries were the result of his imagination. The chief philosopher at the University of Pisa refused when invited to look through the telescope and see for himself, asserting that he would see nothing. About this same man Galileo wrote jokingly to Kepler: 'How you would laugh if you heard what the first philosopher of the faculty of Pisa brought against me in the presence of the Grand Duke, for he tried, now with logical arguments, now with magical adjurations, to tear down and argue the new planets [Jupiter's moons] out of the heavens'. Others, such as a young Lutheran student at Pisa named Horky, resorted to violent abuse of Galileo. The most persistent of his opponents over the years was a Florentine layman named Ludovico delle Colombe, an amateur astronomer of no ability whatever. But he was dangerous because he wielded a good deal of influence, and it was he who first took the sinister move of enlisting the Scriptures against the new discoveries. Galileo was more amused than indignant by the antics of those obscurantists and answered none of them. He guyed Ludovico delle Colombe, whose name means doves or pigeons, by referring to him and his allies as 'The Pigeon League'. He could afford to disdain such people, as he had won the esteem and support of Kepler, an astronomer royal, like himself, of the Jesuit astronomers in Rome, and of a band of brilliant young disciples, mostly ecclesiastics, foremost among them the Benedictine monk, Benedetto Castelli, for whom he had secured the chair of mathematics at the University of Pisa.

GALILEO'S FRIENDSHIP WITH CLAVIUS

On his first visit to Rome at the age of twenty-three Galileo had made the acquaintance of the chief mathematician at the Roman College, an institution founded by St Ignatius Loyola in 1552 and direct ancestor of the present Pontifical Gregorian University. This man, a German named Christopher Clavius (born Christof Clau), played a prominent part in the reform of the calendar carried out under Pope Gregory XIII, and was esteemed for his personal qualities as well as for his mathematics by many of the eminent men of his time. Though he never embraced Copernicanism and indeed had directly combated that theory in an edition of The Sphere of the Yorkshireman John Hollywood, which was the best exposition of the Ptolemaic astronomy in existence, that fact did not prevent Clavius and Galileo becoming and remaining very good friends to the end of the Jesuit's days in 1612. Clavius and his colleagues at the Roman College had acquired a telescope of their own and were able to inform Galileo that they had personally confirmed all his discoveries, news that determined him to visit Rome again in 1611, the year following publication of the Starry Messenger. That he came in the role of a crusader for Copernicus was plain from his own avowal and from the collection of fine telescopes in his baggage. He must once and for all rescue the pope, the college of cardinals, and other eminent men in the Eternal City from their bondage to Aristotle and Ptolemy. He ought to have known better at the age of forty-eight.

THE CAMPAIGN

Our Crusader arrived at his destination on 29 March 1611, and the following day turned his steps

towards the Roman College, where he had discussions with Father Clavius and some other professors who had been studying the 'Medicean Planets' continuously for two months. 'We have compared notes', he informed a friend on 1 April, 'and have found that our observations tally in every respect.' The process of lionization then began. Pope Paul V, the brusque and unpredictable canonist out for the rigour of the law who had put the Republic of Venice under an interdict while Galileo was there, now received that astronomer in a long private audience and assured him of his unalterable good will. That, however, remained to be seen.

Next, the eminent man from Florence was elected a member of the Lincean Academy, the Academy of the Lynx-eyed, which had been founded by Federigo Cesi, son of the powerful Duke of Aquasparta and an enthusiast for the study of philosophy, science, and mathematics. The importance of the Academy, membership of which Galileo greatly prized, lay in the fact that in those days, as contrasted with our times, universities had become hidebound in conservatism, with a vested interest in maintaining the accepted views. The Lincean was the pioneer of many academies which sprang up in imitation of it or for other purposes, and it ante-dated the foundation of the English Royal Society by many years. Prince Cesi and Cardinal Farnese both gave banquets in honour of the man of the hour who, when the feasting and toasting were over, produced his telescopes and invited Cardinal Bellarmine, a good friend of Prince Cesi, as well as other distinguished guests, to view Jupiter's moons and other newly revealed phenomena of the heavens.

ST ROBERT BELLARMINE'S PERPLEXITIES

That what he saw gave Bellarmine, the great and loveable defender of the faith, food for thought is evident from the inquiry which he at once addressed to his life-long friend Clavius and his colleagues at the Roman College. St Robert, like the vast majority of educated people in the Western world, had been bred in the Ptolemaic tradition, and found it difficult at the age of seventy to surrender any of the framework of a system which had served mankind marvellously well for so long a time. He admitted that he had seen through the telescope 'very wonderful things concerning the moon and Venus', and would be grateful for the opinion of the experts on those phenomena, and whether they confirmed that there are multitudes of fixed stars invisible to the naked eye, 'and especially whether the Milky Way and the nebulae are to be regarded as collections of very small stars'. Finally, 'whether it is true that four movable stars revolve round Jupiter, each with a different movement from that of the others, but all the movements being exceedingly swift'. He is anxious to have some definite information about these matters, as he has been hearing conflicting opinions expressed.

With a touch of his habitual courtesy he suggests that they reply on the sheet containing his inquiries. They did, and in every detail except one confirmed Galileo's findings. Clavius in a minority report gave his opinion that the irregularities on the surface of the moon are merely apparent, 'being due to the fact that the lunar mass is not uniformly dense but composed of more rarefied and more solidified sections which last are the ordinary spots one sees with the naked eye'. Clavius was rewarded with a letter from Ludovico delle Colombe, thanking him for defending an unspotted moon! But he wrote too soon, for the eminent Jesuit went over completely to Galileo's view before he died the following year at the age of seventy-six.

The Jesuits of the Roman College played their part in honouring Galileo by organizing a public conference at which he was installed like a king on a throne to listen to Father Odo van Maelcote, one of the signatories of the reply to Cardinal Bellarmine's inquiry, pronouncing an enthusiastic discourse

on the new astronomical discoveries. The students of the College had been well coached in Galileo's views and expounded them to the large assembly with a little too much gusto for the liking of the Aristotelians in the audience. 'We proved clearly', wrote one of them long afterwards to his friend the great Dutch scientist Christian Huygens, 'that Venus revolves round the sun, but not without muttered protests from the philosophers.' Galileo was certainly having the time of his life. Just before his return to Florence in June 1611, Cardinal del Monte addressed a note to the Grand Duke of Tuscany in the following terms: 'During his stay here Galileo has given the greatest satisfaction. I verily believe that were we living under the ancient Roman Republic, a column would have been erected on the Capitol in his honour'. The great man himself wrote: 'Everybody is showing me wonderful kindness, especially the Jesuit Fathers'.

But the eight cardinals of the Holy Office, among them Bellarmine, were more reserved in their attitude to the visitor from Florence. They were not at all concerned to question Galileo's remarkable astronomical discoveries, but may well have wondered whither this extraordinary man was heading in his persistent onslaughts by voice and pen on views accepted by the generality of mankind from time immemorial. The cardinal inquisitors made an inquiry in Venice as to whether Galileo's name had been mentioned in connection with an abortive process against a certain Caesare Cremonini who had been a friend of the Florentine during his Paduan days and was an avowed Averroist. Cardinal Bellarmine liked and admired Galileo, so it is improbable that he initiated the inquiry, as some estimable champions of the scientist are inclined to suggest. In any case, he was not Secretary of the Holy Office. The fact that the inquiry was made does seem to indicate a certain apprehension on the part of the cardinals as to the destructive course on which Galileo was so merrily engaged.

Back in Florence trailing his clouds of glory, the great scientist quickly found himself in head-on collision with the die-hard Aristotelians on a question of physics rather than astronomy. It concerned a topic that had long interested him, the behaviour of bodies placed in water. Why do they float? The Aristotelians had the answer pat: because of their shape. The Grand Duke of Tuscany liked to give public banquets to which he invited distinguished guests. It was hot on one such occasion and ice was obviously provided, for the conversation turned on the reason why that substance floats. Galileo, who was present, had long devoted his splendid talents to this problem and maintained strongly the opinion of Archimedes, the great Sicilian physicist who lived after Aristotle's time, that whether objects in water floated or sank depended in no wise on their shape but on their specific gravity. Ice floats whatever its shape because its weight is less than an equal volume of the water in which it is immersed. Two distinguished visiting cardinals from Rome graced this particular banquet, one of whom, Maffeo Barberini, sided enthusiastically with Galileo against the outraged Aristotelians at table. From that moment Barberini and Galileo became fast friends. History sometimes takes ironical turns, for it was this cardinal who, more than twenty years later, as Pope Urban VIII, brought about the disastrous condemnation of Galileo by the Roman Inquisition.

The Grand Duke was so much impressed by his Principal Mathematician's brilliant argumentation that he urged him to publish his views, which he did in Italian the following spring (1612), calling his book a Discourse on Things that Float or Move on Water. He at once sent a presentation copy of the work to Cardinal Bellarmine, who replied in the following terms:
'Illustrious Signore, I have received your letter and the accompanying treatise . . . I shall read it with much pleasure, sure as I am that it is a work worthy of so eminent an author. While thanking you most heartily for your courtesy in sending it to me, I would like to assure you that the affection you have thus shown me is fully reciprocated on my part, and you will see that this is so, if ever I get an opportunity of doing you a service'. St Robert was not the kind of man to indulge in empty compliments, and three years later did Galileo, whose splendid talents and deep Catholic faith he fully

appreciated, a very important service indeed. In reading the Discourse on Floating Bodies, he must have been saddened by the author's habit of ridiculing his opponents. In the book Galileo had amused himself by anticipating the various arguments of the Aristotelians, giving them new force, adding others that had not occurred to them, and then bringing the whole house of cards tumbling about their heads by his own brilliant demonstrations. It made them understandably wild, and no book of his was attacked by them more often or more savagely, Ludovico delle Colombe always in the lead. Robert Bellarmine was the kindliest of men and could not understand his eminent friend's brutal determination to wound.

SUNSPOTS AND THE ROTATION OF THE SUN

In his next important work, History and Demonstrations concerning Sunspots and their Phenomena, Galileo kept a bridle on his unkind wit and treated his opponent, Christopher Scheiner, a Jesuit astronomer at the University of Ingolstadt, with genuine courtesy, though he knew him only under his pseudonym of Apelles. Sunspots were very active at this time and Scheiner, as well as Galileo and others, had been studying them carefully. Scheiner made known his findings in a series of letters to his good friend Mark Welser, a wealthy member of the famous Augsburg banking family and a devout Catholic who was also an enthusiastic and very open-minded amateur of science. Welser promptly published the letters, and sent a copy of the book to Galileo, asking for his views. He wrote in excellent Italian and Galileo felt entitled to reply in the same language, which unfortunately Scheiner did not know. Scheiner was a man of genuinely scientific instincts and made some contributions of merit to astronomical theory, but he was badly hampered in his investigations and experiments by belief in that prime Aristotelian dogma, the immaculacy and immutability of the sun, the moon, and the other heavenly orbs. The spots, he suggested, were in fact small stars circling round the sun. Galileo, who was impeded by no scruple for immaculacy, proved that the spots could not be stars, that they were close to the surface of the sun, and that that luminary turned on its axis, just as did the earth.

His three great letters to Mark Welser, who had himself been elected to the Lincean Academy, were published in their native Italian by that organization in Rome in 1613. Father Grienberger, the best of the Jesuit astronomers now that Clavius was dead, at first sided with Scheiner, but subsequently went over to Galileo's views. The good Scheiner himself was much shaken when at last he was able to read Galileo's letters in a Latin translation. In the book Galileo pronounced unequivocally, if still a little vaguely, in favour of the Copernican system of astronomy, not as a mere hypothesis but as established physical fact, and predicted its forthcoming triumph, yet there was not a word of protest from any ecclesiastical authority, and the only shouting came from the lay Aristotelians.

THE BIBLE AS A WEAPON AGAINST COPERNICANISM

But just at this noontide of his success and popularity, a small but menacing cloud appeared on Galileo's horizon, conjured in perfect innocence by his most intelligent and enthusiastic disciple, the young Benedictine monk, Benedetto Castelli. At another of the public banquets for distinguished guests which Grand Duke Cosimo II gave, Castelli was present but not Galileo, who lay ill in bed at the time. Cosimo's mother, Grand Duchess Christina of Lorraine, asked an esteemed guest, Professor Boscaglia, who expounded Plato at the University of Pisa, what he thought of Galileo's discoveries. He answered that they were undoubtedly real, but that the movement of the earth which Galileo deduced from them

could not be true as it was obviously contrary to the Holy Scriptures. The dinner came to an end and Father Castelli had departed for his monastery when a messenger from the Grand Duchess summoned him back. The great lady began at once to argue the Scriptures against the Copernican views Castelli was known to entertain, though strictly forbidden to teach at the University. He took her up with spirit and was supported by a number of the eminent persons present. 'I started to play the theologian with such assurance and dignity', he informed Galileo, 'that it would have done you good to hear me. I carried things off like a paladin.' He was very young.

Galileo, sensing danger in the situation, replied with a very long letter, giving his opinions on the relations that ought to exist between science and the Scriptures, later amended and expanded into the famous Letter to the Grand Duchess Christina, in which by some magic of genius he largely anticipated the teachings of Pope Pius XII's encyclical, Divino Afflante Spiritu, promulgated in 1943, four centuries after the publication of Copernicus's De Revolutionibus Orbium Caelestium. Galileo did not dare to have his Letter printed and published just then, but many manuscript copies of it were made by his disciples, particularly Castelli, who unwisely left some of them lying about in Pisa.

Meantime, on 21 December 1614, a hot-headed Dominican friar named Tommaso Caccini preached a sensational sermon at the beautiful priory church of Santa Maria Novella, Florence, denouncing in unmeasured terms the Copernican views then being widely aired in the city by 'Galileans', and expressing a hearty wish that all mathematicians should be banished from Christian states as fomenters of heresy. Caccini's religious brethren were outraged by his inflammatory discourse, not by any means his first offence, and denounced him to the Master General of the Dominican Order in Rome, Fra Luigi Maraffi, a man with a genuine respect and even admiration for Galileo's great qualities, who now promptly and whole-heartedly apologized to him for Caccini's conduct.

Shortly after that person's outburst, a Dominican priest of a different stamp but equally set in his ways, Niccolo Lorini, a Florentine patrician aged seventy, much esteemed by the Grand Duke and others who knew him, paid a visit to Pisa and there came upon a copy of Galileo's Letter to Castelli. He read it and was profoundly shocked by its contents. Three years earlier he had admitted to Galileo that he knew nothing about mathematics or astronomy, and was totally uninterested in this 'Ipernic or whatever his name is'. Now, he suddenly developed a very strong interest in the same 'Ipernic', copied the Letter out in full, and returned in hot haste to consult with his brethren at the Convent of San Marco, amid the exquisite frescoes of {Blessed} Fra Angelico. He then wrote on their behalf to Cardinal Paolo Sfondrati, Secretary of the Holy Office at Rome, on 7 February 1615, denouncing Galileo and his disciples for taking upon themselves 'to expound the Holy Scriptures according to their private lights and in a manner different from that of the common interpretation of the Fathers of the Church', for striving 'to defend an opinion which appeared to be quite contrary to the sacred text', for 'treading under foot the entire philosophy of Aristotle which has been of such service to scholastic theology', and, in fine, 'for airing and scattering abroad in our steadfastly Catholic city a thousand saucy and irreverent surmises, just to show their cleverness'. He says that Galileo's Letter was 'in everybody's hands', and he writes to acquaint the Lord Cardinal with the deplorable state of affairs 'that you in your holy zeal for the faith may, in conjunction with your illustrious colleagues, provide such remedies as will appear advisable'.

GALILEO WRITES TO ROME

Galileo, suspecting that there was something in the wind, wrote shortly afterwards, on 16 February, to

one of his most trusted advisers in Rome, Archbishop Piero Dini, enclosing an accurate copy of his Letter. He was still smarting under Caccini's attack and believed him to be behind the denunciation to the Holy Office, but in that he was incorrect as Caccini did not even know of the existence of the Letter. But some miscreant had interfered with the text of Lorini's letter to Cardinal Sfondrati, for where Galileo wrote that the Scriptures sometimes overshadow their own meaning, the word 'overshadow' was changed to 'pervert', and the word 'false' was intruded in another place. He asks Dini greatly to oblige him by reading his authentic copy to Father Grienberger at the Roman College, 'that excellent mathematician and my very dear friend and patron'. He also suggests that it be brought to the notice of Cardinal Bellarmine, 'as I am given to understand that these Dominican Fathers are proposing to apply to his Lordship, in hopes of securing at least the condemnation of the book and teachings of Copernicus'. Galileo would have been considerably relieved had he known the fate of his Letter denounced to the Holy Office. Cardinal Sfondrati had submitted it to a consultor of that body, almost certainly a Dominican, for his judgement, and the excellent man found it to be blameless and quite in accord with Catholic teaching, except for the two forged words.

Mgr Dini had to delay his reply to Galileo until 7 March owing to the prolonged carnival celebrations which made ordinary business impossible in Rome. He made up for the delay by having several copies of Galileo's Letter to Castelli transcribed, one of which he subsequently delivered to Father Grienberger.

He also had a long audience with Cardinal Bellarmine, who assured him that since Galileo and himself had discussed the astronomical question together in 1611 , he had never once heard it ventilated in any way. 'As to Copernicus, his Lordship said that he could not believe his work would be forbidden, and that the worst possibility, in his opinion, would be the insertion of a note stating that the theory was introduced to save the celestial appearances, or some similar expression, in the same way as epicycles had been introduced. With this reservation, he continued, you would be at liberty to speak freely on these matters whenever you liked. It seemed to him that the passage of Scripture most opposed to the new interpretation of the celestial phenomena was the Psalmist's text referring to the sun. "Like a strong man it runs its course with joy. Its rising is from the end of the heavens, and its circuit to the end of them" (Ps. 19:6-7; Douay, 18). He said that all commentators up to the present time have understood it to imply that the sun is in motion. I answered that the Holy Scriptures might be considered in this place as simply employing our usual form of speech, but the Cardinal said that in dealing with such a question we must not be too hasty, just as it would not be right to rush into condemnation of anyone for holding the views which I had put before him . . . He told me that he intended to invite Father Grienberger to his house that he might discuss the question with him, and this very morning I have been to visit the Father, to see if there were any further news. I found that there was nothing fresh except that Father Grienberger would have been better pleased if you had first given your proofs before beginning to speak about the Holy Scriptures . . . As for the arguments which I advanced in support of your views, the Father said that he doubted whether they were not more plausible than true . . .'

GALILEO'S JUSTIFICATION

They were so very plausible that Galileo was certainly entitled to regard them as conclusive, even though it was not until 1727, with the English astronomer Bradley's discovery of the aberration of light, that the first direct observational proof of the Copernican theory was found, and another hundred years before the German astronomer Friedrich Bessel clinched it by determining, after years of patient observation, the annual parallax, or apparent very slight displacement, of the star 61, in the

constellation of the Swan. Both Copernicus and Galileo himself knew well that there should have been such a parallax if their theory was a physical fact, and their inability to discover it troubled them considerably. Still, Galileo at least had enough reasons to justify his confidence in Copernicanism, in the rotation of the sun on its axis, the phases of Venus and above all the moons of Jupiter. He was also perfectly entitled to reject St Robert Bellarmine's rather naive invitation to regard the Copernican theory as a mere hypothesis to account for the face of the heavens. Besides being a great scientist, he was the first profound theoretician of science and knew in his bones that its business was to attain to the structure of reality, that hypotheses are formulated, not to save appearances, but to be verified or rejected by experiment, and also to try to bring a great unifying principle into the diversity of phenomena. Through his own telescopic discoveries he had already made an enormous contribution to the unifying principle by proving that the material of the heavens, of the sun and of the moon, was no privileged fifth incorruptible essence, but the same changeable elements that compose the earth.

Had Galileo avoided trying to play the lay theologian, he might well have escaped all molestation. True, he played the role extremely well, and much better, at least in the matter of the Scriptures, than the great professional Robert Bellarmine. But that was not the point. Bellarmine's rather 'fundamentalist' views were not special to him, but widespread at the time and, in a sense, inevitable, owing to the cautionary and defensive attitude with regard to the Scriptures forced on the Church by the Protestant misuse of them. Galileo's steadfast friend and counsellor Mgr Dini had advised him again and again 'to keep out of the sacristy', to stick to physical arguments and leave the Scriptures alone. Another devoted friend, a young official named Giovanni Ciampoli, wrote to tell Galileo that he had had a conversation with Cardinal Barberini, an ardent admirer of the scientist's genius, who was of opinion that 'the more prudent course in dealing with these matters would be to confine oneself to the reasons given by Ptolemy or Copernicus, and not to employ any other except physical and mathematical arguments, as the theologians consider the exposition of the Sacred Scriptures to be their province'. Three weeks later, Ciampoli wrote again to tell of an interview that he and Archbishop Dini had had with Cardinal del Monte: 'Cardinal del Monte told us that he had discussed the question of Copernicanism at great length with Cardinal Bellarmine and that they had concluded as follows, "If you treat of the system of Copernicus and set forth its proofs without bringing in the Scriptures, the interpretation of which is the business of qualified theologians, then you should not be opposed in any way whatever . . ." '

THE FATEFUL BOOK OF AN EMINENT CARMELITE

In that same year, 1615, a fateful book appeared at Naples in the shape of a Letter to the General of the Carmelites by one of his most eminent subjects, Reverend Father Paul Anthony Foscarini, Carmelite, concerning the Opinion of Pythagoras and Copernicus on the Motion of the Earth and the Immobility of the Sun. This book did precisely what all his well-wishers urgently advised Galileo not to do. It brought the Scriptures directly into the debate on heliocentrism and endeavoured to show that, on a proper interpretation, they were not in the least in conflict with that theory. Foscarini was so confident of the rightness of his action that he posted a copy of his book to Cardinal Bellarmine and also came to Rome to preach on the subject of his book and to take on all comers in defence of it. Considering the feeling of the time and the known conservative attitude of the Holy Office, that was surely a highly provocative course, but Prince Cesi and Father Castelli, who were young and ardent, thought it a marvellous piece of good luck that a distinguished Carmelite priest should have come out so openly in Galileo's favour. Galileo, to whom Cesi had sent a copy of the book, thought so too. But not Robert Bellarmine.

In a very courteous reply to Foscarini, he thanked him warmly for the book, which he found 'replete with skill and learning'. As for his general opinion of the book, he says: 'It seems to me that your Reverence and Signor Galileo would act prudently were you to content yourselves with speaking hypothetically and not absolutely, as I have always believed that Copernicus spoke'. Not Copernicus but Osiander, whose bogus preface deceived St Robert and countless other people. 'But to want to affirm', he continues, 'that the sun is in very truth at the centre of the universe and only rotates on its axis without going from east to west, and that the earth is situated in the third sphere and revolves very swiftly round the sun, is a very dangerous attitude and one calculated not only to annoy all scholastic philosophers and theologians, but also to injure our holy faith by contradicting the Scriptures. Your Reverence has clearly shown that there are several ways of interpreting the Word of God, but you have not applied those methods to any particular passage, and I feel certain that you would have met with the very greatest difficulties had you wished to expound by the method of your choice all the texts which you have cited.'

The good Cardinal, who was seventy-four and very, very tired, was not quite conversant with more recent Scriptural exegesis, for he still maintained that the Fathers of the Church and all modern commentators, both Latin and Greek, had interpreted the texts relative to the motion of the sun in the way he had been taught in his youth and could not then disavow. He went on to say that if there were a real proof that the sun was at the centre of the universe and that the earth went round it, 'we should have to proceed with great circumspection in explaining passages of Scripture which appear to teach the contrary, and rather admit that we did not understand them than declare an opinion to be false which is proved to be true. But for myself, I shall not believe that there are such proofs until they are shown to me'.

Quite plainly St Robert did not believe in a convergence of strong probabilities as affording a reasonable proof, and equally plainly he had not read Galileo's Letter to Castelli where that superb genius had already replied to most of his arguments. Had the old Cardinal wished for a showdown with the Copernicans whose views he believed to be both erroneous and dangerous, Foscarini's book would certainly have afforded him an occasion, but he took no such step and ended his long letter to the Carmelite with the words: 'I salute your Paternity affectionately and pray God to grant you all happiness. Your very Reverend Paternity's Brother, Cardinal Bellarmine'. One of the very best living authorities on the Galileo case, Mr Stillman Drake, who has produced translations of many of the great man's works and furnished them with admirable introductions, pronounces the following judgement on Bellarmine's attitude in the controversy: 'Bellarmine had given Foscarini a written opinion, without asking for an official ruling, and although he associated Galileo's views with Foscarini's in this, he had not reported the matter to the investigating body. Yet he knew very well that Galileo was under scrutiny. His actions suggest that truly responsible officials did not particularly wish to see an official ruling on the points in dispute' (Discoveries and Opinions of Galileo, New York, 1957, p. 217). Alas, Galileo forced their hands.

GALILEO DESCENDS ON ROME AGAIN

Against the wishes of the Master General of the Dominicans, his subject Tommaso Caccini came to Rome and constituted himself there principal defender of the faith against the wicked Copernican errors. To counteract this man's nefarious activities, Galileo decided that he also must once again visit Rome and arrived there on 7 December 1615, fortified with commendatory letters from the Grand

Duke of Tuscany. From this point on, his fateful story unfolds with all the grim inevitability of a Greek tragedy. In his Letter to Castelli, revised and amplified in the Letter to the Grand Duchess Christina, Galileo assumed that the inspired writers of the Scriptures knew perfectly well that the earth went round the sun (which they obviously did not, as such scientific knowledge is no part of the 'salvation history' with which alone the Bible is concerned), but stated the opposite 'lest the shallow minds of the common people' should be disturbed in their faith. {Clearly, the Divine author of Holy Scripture knows all the facts about His creation, but that is not necessarily true of the Human authors whom He inspired. They were limited to recording the facts and the truth in the best language they were capable of composing. Certainly they would never have consented to deliberately mislead those for whom they were writing. Galileo, however had a lower view of the Bible's mass audience.} He was undoubtedly something of an intellectual snob and had little but contempt for the views and convictions of the common run of mankind, the 'herd', as he called them, but the pope, the cardinals, the bishops and other pastors of souls had a very tender regard for the faith of the masses and did not want it unnecessarily strained.

Two years earlier, in 1613, Galileo had avowed to Vinta, secretary of the Grand Duke, that 'all his life and being henceforward depended' on bringing the world to accept Copernicanism as a physical truth. It was not so much the matter itself, which they would have willingly shelved or left to lie dormant, had Galileo given them half a chance, but the manner of his propaganda, which distressed the responsible authorities. They deprecated his headlong precipitancy in forcing the issue when he might have quietly discussed the Copernican question with intelligent men or used the Lincean Academy as his forum. Scientists today, at least the genuine ones, not their mere rowdy camp-followers, do not go tub-thumping at the public forum in Hyde Park, London, or seek a hearing for their abstruse views in the columns of the popular press. They contribute their findings to learned specialized journals, or ventilate them in the serene atmosphere of the Royal Society or at meetings of the British Association for the Advancement of Science, and equivalent organizations in other countries.

Galileo himself, however, was full of optimism. Five days after his arrival at the centre of Christendom he wrote to tell his good friend Curzio Picchena, the new secretary of the Grand Duke, that he found the way clear to maintain and increase his reputation, and felt so satisfied that his health, recently very bad, 'was improving not a little in consequence'. From all accounts he took an unholy delight in baiting and exasperating the peripatetic backwoodsmen. Another of his many priest friends and admirers, Antonio Querengo, said in a letter of 20 January 1616, to Cardinal d'Este at Modena: 'Your Lordship would enjoy Galileo's discourses immensely. He turns the laugh against all his opponents and answers their objections in such a way as to make them look perfectly ridiculous'. Hardly the best way to make friends and influence people!

The Tuscan ambassador in Rome, Piero Guicciardini, was much alarmed when he heard that Galileo had decided to come to Rome again, for he would be responsible for him and he knew well his battling proclivities. After watching his protégé's antics helplessly for about two months, the Ambassador wrote in real anxiety on 4 March to Galileo's friend in Florence, Curzio Picchena, for he also knew the uncertain temper of Pope Paul V: 'Galileo sets more store by his own opinions than by the advice of his friends. Cardinal del Monte and myself (though my influence with the man is small), as well as other cardinals of the Holy Office, have endeavoured to pacify him and persuade him not to stir up this affair, but if he wished to hold his views to hold them quietly, without using so much violence in his attempts to force others into holding them. We all doubt very much whether his coming here is not going to prove prejudicial and dangerous for him . . .' He goes on to tell that Galileo, 'after bothering and annoying several cardinals with his story', concentrated on the youngest and least experienced of them, Cardinal Orsini, whose age was twenty-two. Like so many of his generation, Orsini was a strong

supporter of Galileo and spoke to the Pope in a consistory on his behalf. The Pope replied that it would be a good thing if he could persuade his friend to abandon his views. Orsini persisted in his advocacy, whereupon the Pope brusquely informed him that the whole question had been referred to the cardinals of the Holy Office. Galileo had well and truly set the stage for his own undoing.

THE CONSEQUENCES

Why was Galileo in such an unaccountable hurry? He believed completely in the physical truth of Copernicanism and was certain that it would eventually be recognized by all mankind, and that was also probably the private opinion of such astronomers as Father Grienberger, who must have felt that Tycho Brahe's theory to which they provisionally adhered was only a half-way stage to full heliocentrism. But they wanted this to be borne in on men's minds gradually, without too great a dislocation of traditional thinking. Galileo, on the contrary, wanted Copernicanism to be accepted almost overnight, and thereby hangs the miserable and entirely unnecessary tale of his condemnation. The cardinals of the Holy Office submitted two propositions for the verdict of their eleven consultant theologians, many of them highly accomplished in their own discipline, but quite without competence in the sphere of physical science or astronomy. On the first proposition, that the sun is at the centre of the world and altogether devoid of local motion, they pronounced unanimously that it was foolish and absurd philosophically, and formally heretical as contradicting the doctrine of Holy Scripture in many places. On the second proposition, that the earth is not at the centre of the world but moves as a whole and also with a diurnal motion, they were all agreed that it merited the same censure in philosophy and, from a theological standpoint, was at least erroneous in the faith.

Those lamentable pronouncements have been the delight of anti-Catholic propagandists ever since they were made. The critics tend conveniently to forget the very much larger number of priests and theologians who stood by Galileo and remained his steadfast friends to the day of his death. As for the notorious eleven, the critics are welcome to them. They were disavowed even by the eight cardinals of the Holy Office who refused to accept their verdicts as they stood. They did not publish the theologians' findings, but eliminated the word heretical from them and then consigned them to the oblivion of the Holy Office's files where they remained gathering dust and forgotten for seventeen years. Several Jesuit Fathers confided to Prince Cesi that they were astonished and greatly displeased by the decision against the eminent scientist. But Galileo was not to get off scot-free. By direction of the authoritarian Pope, who had put the Republic of Venice under an interdict and gravely increased the burdens of the persecuted Catholics in England by forbidding them to take the new oath of allegiance to King James the First, the Crusader from Florence was to appear privately before Cardinal Bellarmine on 25 February 1616 and be admonished to abandon the propositions condemned the previous day by the eleven theologians, though he could continue to hold and defend them as hypotheses. We have St Robert Bellarmine's written testimony for it that he acquiesced.

Our hero remained on in Rome for three months after the decision had gone against him and, during that time at least, did not feel particularly depressed. Indeed, he informed friends in Florence and elsewhere that he had won a signal victory over his malign and ignorant enemies. Pope Paul V, the rigid canonist, with so little understanding of or care for the complexities of human situations, gave Galileo, whom he had humiliated, an audience lasting forty-five minutes. He said it was a 'most friendly audience', and wrote happily about it the following day, 12 March 1616, to the Tuscan secretary of state at Florence: 'I made known to his Holiness the malice of my persecutors and some of their calumnies against me. He answered that he was well aware of my uprightness and sincerity of mind and, when I

still showed some anxiety about the future, he consoled me and said that I might put away all care because I was held in so much esteem by himself and by the whole college of cardinals that they would not lightly lend their ears to calumnious reports. During his lifetime I might feel quite secure, and before I took my departure he assured me several times that he bore me the greatest goodwill, and was ready to show his affection and favour towards me on all occasions'.

Genial words and promises could not undo the damage already done by the Pope in handing over a matter of strictly scientific interest to cardinals and consultors wholly incompetent to pronounce on it. As for the Scriptural question, Galileo himself had proved up to the hilt that Scripture need not be interpreted as opposed to heliocentrism, but none of the people involved took the trouble to study his great Letter to the Grand Duchess Christina, though there were plenty of manuscript copies to be consulted. Neither that Letter nor any other writings of Galileo were forbidden, but poor Foscarini suffered a different fate and his Letter was absolutely banned, and its publisher imprisoned at Naples. Foscarini died the same year, possibly of grief.

To stop the mouths of such mischief-makers as Caccini, who spread rumours that he had been compelled to recant his opinions and been given a salutary penance, Galileo applied confidently to Cardinal Bellarmine for a certificate as to what had really happened in his presence. The old man readily agreed and wrote the following lines for him: 'We, Robert, Cardinal Bellarmine, having heard that Signor Galileo Galilei has been calumniously reported to have abjured in our hand, and moreover to have been punished with a salutary penance, declare that the said Galileo Galilei has not abjured in our hand, nor in the hand of anybody else here in Rome, nor, so far as we are aware, in any place whatever, any opinion or doctrine held by him [i.e., Copernicanism as a hypothesis]; neither has any penance, salutary or otherwise, been imposed upon him. All that happened was this. The declaration made by the Holy Father and published by the Sacred Congregation of the Index was intimated to him, wherein it is declared that the doctrine attributed to Copernicus, that the earth moves round the sun and that the sun is in the centre of the universe and does not move from east to west, is contrary to the Holy Scriptures, and therefore cannot be defended nor held [except as a mathematical hypothesis]. In witness whereof we have written and subscribed these presents with our own hand the 26th day of May, 1616. Robert Cardinal Bellarmine'. Galileo carefully preserved that certificate among his papers and produced it as his chief defence during his trial in 1633, when Cardinal Bellarmine had been twelve years in his grave.

BACK IN FLORENCE

Though he put a brave face on his failure in Rome, Galileo, back in Florence by order of the Grand Duke who wished to keep him out of further trouble, felt bitterly aggrieved that he had been unable to convert the world generally by the persuasiveness of his tongue. He remained out of the public eye for two years after his return home, being mostly unwell, but early in 1618 his old fighting spirit revived a little and he began to cast around for some way of presenting his Copernican convictions indirectly, as he was precluded from championing them openly. If he could only hit upon some solid physical proof of the movement of the earth round the sun and on its own axis that would satisfy such a patently honest man as Cardinal Bellarmine and render him less rigid on the Scriptural question, he might yet win the day for Copernicus. While in Rome in 1616, he turned his attention to the phenomenon of the tides and persuaded himself that they were due to the combined axial and orbital movements of the earth. In other words, the tides proved that the earth was in orbit round the sun. The tides, as we in our superior knowledge understand, are caused by the attraction exerted upon the seas of the earth by the

Moon and to a lesser extent by the Sun.

It is very strange that so great a man as Galileo should have clung pertinaciously to his completely erroneous theory, which contradicted the plainly observable facts, for the rest of his life. In his excellent book on the history of scientific opinion through the ages, The Sleepwalkers (1959), Arthur Koestler suggests that he clung to his view as a desperate sort of substitute or compensation for the parallax of a fixed star which he knew to be necessary for the physical truth of Copernicanism and which he was unequipped to discover. It became, as another eminent historian of scientific theory has written, his 'secret weapon'. We pygmies ought to feel great sympathy for him in his delusion. He had written his essay on the tides in the first place for the young Cardinal Orsini, his ardent supporter, and tried in 1618 to get it published in Austria, with a preface describing it as a mere poetical conceit or dream. It was indeed just that but he never recognized the fact.

While this trial balloon was in the air, an event occurred which gave Galileo a safer if much less direct approach to his problem. In the autumn of 1618, three comets appeared in rapid succession, the last very bright one remaining visible until January. The Thirty Years War had already begun and astrologers interpreted the comets as a foreboding of terrible things to come. To counteract such views a Jesuit astronomer at the Roman College named Orazio Grassi, designer of the great church of San Ignacio, Rome, gave a lecture on comets, subsequently published, in which he stated the correct view that comets move in regular orbits, out far beyond the moon. In support of this he cited Tycho Brahe's observations of the comet of 1577 which had seriously damaged the Aristotelian conception of the heavens. Galileo's astronomical discoveries as recounted in the Starry Messenger had laid the Aristotelian firmament in ruins.

He read Grassi's essay and, not being exactly the most meek and humble of men, was intensely annoyed to find that the Jesuit never once mentioned his name in it. As it had become a highly controversial name, Grassi may have omitted it for reasons of prudence, without meaning any slight to the famous scientist whom the Roman College had been delighted to honour. However, he took great offence and scribbled in the margins of the little booklet such expressions as 'piece of asininity', 'buffoon', 'evil poltroon', 'ungrateful villain'. In his work on sunspots, he had endorsed Tycho Brahe's views on comets, just as did Grassi, but now in his irritation he completely reversed that opinion and maintained that comets had no real existence but were optical illusions connected with the earth's atmosphere. He wrote an angry answer to Grassi but, not wishing to become involved in controversy with a Jesuit, got his pupil Mario Guiducci to sign it and pretend that it was his. Grassi saw through the ruse and, to his everlasting discomfiture, replied hotly to Galileo himself under the nom de guerre of Lothario Sarsi. That was in 1619. Galileo took his time in answering and did not publish his devastating retort until 1623. Grassi, alias Sarsi, had named his book The Astronomical and Philosophical Scales, referring to the sign of the Zodiac in which he incorrectly thought that the comet studied by Tycho Brahe had appeared. In these scales he would weigh Galileo's arguments, a dreadful piece of folly if he knew anything at all about the man he was tackling, the most deadly controversialist of his age. Galileo took him up on his title and called his answer The Assayer, thus replacing Sarsi's crude steelyard with the delicate instrument that is used in the assay of pure gold.

GALILEO MAKES MINCED-MEAT OF GRASSI

The Assayer is an amazing compound of conceit, brilliant sophistries and sarcasms, and profound scientific insights. It is written in the form of a letter to yet another of his ecclesiastical friends, the

Very Reverend Monsignor Don Virginio Cesarini, Lincean Academician and Chamberlain to His Holiness the Pope. Beginning with a tirade against all those who had tried to rob him of the glory of his discoveries, he writes: 'You cannot help it, Signor Sarsi, that it was granted to me alone to discover all the new phenomena in the sky and nothing to anybody else. This is the truth which neither envy nor malice can suppress'. Next, he attempts to demolish the reputation of Tycho Brahe by speaking of his 'alleged observations' and referring to comets as 'Tycho's monkey-planets'. Then he indignantly denies that he had anything to do with Guiducci's essay on comets beyond discussing the matter with the author. Unfortunately for that contention, most of the manuscript survives, written in his own hand.

In the midst of the irrelevancies and very witty, though often unfair, sallies at Sarsi's expense, there occur other passages which are classics of scientific reasoning, of the experimental method, of the duty to be sceptical about quoting authorities and of not treating Aristotle as though he alone had been given eyes to see for all the generations of mankind. In The Assayer, too, is to be found the distinction, perfectly illustrated, between the primary and secondary qualities of material things which anticipated the fundamental concepts of the empiricist philosophy developed chiefly by John Locke. But Galileo was far from being a philosophical empiricist, and attached no less importance to reason than to experiment, nor did he ever entertain the slightest doubt about the independent truth of mathematical propositions. The Assayer, with all its flaws, was truly an epoch-making book, a very great scientist's scientific manifesto.

Galileo had an enormous piece of good fortune in the publication of his book, for it coincided with the election to the papacy of his old friend and admirer, Maffeo Barberini, as Pope Urban the Eighth, and he was able to dedicate The Assayer to him. The Pope thoroughly enjoyed the book and, when its author came to Rome, where it was published, in the spring of 1624 accorded him six long audiences in the space of six weeks, gave him a pension for his son, a valuable work of art, and gold and silver medals. In a testimonial to the new Grand Duke, Ferdinand II, who stood by Galileo as faithfully as Cosimo had done, Pope Urban extolled the virtues and piety of this 'great man, whose fame shines in the heavens, and on earth goes far and wide'. But much appreciated though he undoubtedly was, Galileo could not persuade the Pope to rescind the decree of 1616, which Urban pointed out had not condemned Copernicanism as heretical but only, in the then state of knowledge, as reckless. Galileo certainly gathered from the Pope that he could say what he pleased in support of Copernicus, provided he kept clear of theological and Scriptural arguments and spoke hypothetically.

Thus fortified, and interpreting the Pope's advice very elastically, he returned to Florence to complete his magnificent Dialogue on the Two Great World Systems, which was to prove disastrous for him. In the Dialogue he defended Copernicanism openly as established physical truth, using as his principal argument his 'secret weapon', the completely erroneous theory of the tides. At the very end of the work, he put into the mouth of Simplicio, the third character and fool of the discussion, an argument suggested to him by Pope Urban, adding to it a characteristic piece of sarcasm. He certainly did not intend to insult his patron and benefactor of so many years, but he seems to have become incapable of resisting a witty sally when it occurred to him.

Urban, however, a very proud man, chose to be deeply offended when the passage was brought to his notice.

Not even the most ardent admirer of Galileo can deny that he resorted to very shifty practices to obtain an imprimatur for his Dialogue. Through a cabal of his friends in Rome, he extorted from the very genial and friendly Master of the Sacred Palace, the Dominican Niccolo Riccardi, a very reluctant permission to have the work printed and censored in Florence, where by other underhand manoeuvres

he secured a censor who was entirely under his thumb. Riccardi protested in vain, and was eventually cajoled and brow-beaten into letting his imprimatur appear on the book. Poor Riccardi, a portly and loveable man, got into serious trouble, and it is not easy to forgive Galileo for causing it. The Dialogue was published at Florence in February 1632. It did not take the Pope and the Holy Office authorities very long to discover that they had been completely outwitted.

GALILEO IS SUMMONED TO ROME BY THE POPE

Six months later, the printer of the book was ordered from Rome to suspend further sales, and in October Galileo was peremptorily summoned to Rome to stand his trial before the Inquisition for flagrant disobedience to the commands laid upon him in 1616. He delayed coming until February 1633, on pleas of illness in which he was supported by protests from Grand Duke Ferdinand and by certificates from doctors. The ill health was genuine enough, but Pope Urban remained inexorable. The fact that he came at all when he could easily have slipped into Switzerland or some other place where the Pope's writ did not run is proof of his strong Catholic faith, as also, no doubt, of his overweening self-confidence. He took up residence at the Tuscan Embassy, the sumptuous Villa Medici, and remained there undisturbed, nursing his health and seeing his Roman friends, for three months.

The evidence would seem to indicate that Urban VIII regarded Galileo's trial as very much of a side-show. The autocratic and ambitious Pontiff had far more weighty matters for his concern, and these were to make himself and his relatives glorious. Maffeo Barberini had served the Church well as a diplomat, but Pope Urban VIII abandoned the delicate position which his far worthier predecessor, Gregory XV, had adroitly managed to keep during the ever-changing fortunes of the Thirty Years War. 'To the disgust and rage of the Catholic princes, Urban openly supported Richelieu who with his Protestant allies was determined to crush Catholic Austria.' Urban also squandered the patrimony of the Church on his wretched relatives, several of whom he made cardinals and placed others in lucrative positions. 'It has been estimated that this Pope's family was enriched by 105 million scudi' during his twenty-one years' reign. Where in Rome are not the bees of Urban's escutcheon, those busy Barberini bees, to be found?

For the glory of his name and the vanity of his kin, artists and artisans were kept hard at work on elaborate fortifications for Rome and on such grandiose structures as the Barberini Palace and the villa of Castel Gandolfo, still the summer residence of the popes. In spite of the classical scholarship of which he was proud, he had no regard for the monuments of antiquity but plundered them to serve his own vainglorious purposes, thus giving rise to the Roman gibe, 'What the barbarians did not do, the Barberini did'. He is sometimes said to have shown kindness to the great Englishwoman Mary Ward, but the Vatican archivist and professor, Joseph Grisar, who is an authority on Mary's history, has for the Pope's attitude to her only one word, 'perfidious'. 'Infected by the same greedy ambitions which had already intoxicated his nephews, the Pope sent his troops to occupy the Duchy of Castro, property of the Farnese family, but the unjust encroachment alarmed and angered the other great clans and principalities to such an extent' that they joined forces with the Farnese Duke, invaded the Papal States, and forced Urban to deliver the usurped domain back to its lawful owner. By the end of his long reign, the prestige of the papacy had declined disastrously both in Italy and beyond the Alps. But his record is not entirely black. He enacted valuable legislation reserving to the Holy See the beatification as well as the canonization of saints, and above all he founded the College of Propaganda, called after him to this day the Urbanum, which is still rendering the Church notable service.

But the most fatal thing which Urban VIII did during his long pontificate, the action with the most far-reaching consequences, was to initiate, possibly to some extent at least out of personal resentment, the trial of Galileo. True, he treated the arraigned genius with the greatest possible consideration, but if he, who had once so unreservedly admired Galileo, had only been magnanimous enough to turn a blind eye on his tricks to get the Dialogue published and had allowed it to appear without hindrance, nobody's faith would have been affected and the world would have been spared an immense amount of hot air on the subject of religion's supposed hostility to science. The fact that Galileo's condemnation is the only case that the critics of the Church seem able to produce is proof enough to the contrary, as Cardinal Newman liked to emphasize.

GALILEO IN THE HANDS OF THE INQUISITION

The illustrious defendant was obliged at last to surrender himself formally to the Inquisition, but he was not, as usual in such cases, put in prison. He was assigned a comfortable suite of rooms, usually occupied by high functionaries of the Inquisition, in the Holy Office headquarters. These are situated alongside the Dominican church of Santa Maria sopra Minerva and close to the Pantheon or St Mary of the Martyrs, which Urban VIII had rifled of its lead and bronze. Galileo was permitted to have the service of a valet, and the Tuscan ambassador's major-domo was allowed in to see to his food and wine. There he stayed under an extremely mild form of house arrest for a month and then, even before his trial was concluded, was accorded permission to return to the Villa Medici, 'a procedure quite unheard of, not only in the annals of the Inquisition but of any other judiciary. Contrary to legend, Galileo never spent a day of his life in a prison cell' (Koestler, The Sleepwalkers, p. 490).

The accused was interrogated for the first time on 12 April 1633 by Fra Vincenzo Firenzuola, the Dominican Commissary of the Inquisition, who startled his man by reading to him a document from the Vatican archives to the effect that he had been given an absolute injunction in 1616 against 'holding, teaching, or defending in any way whatsoever, either by word of mouth or by the written word' the Copernican doctrine. No wonder Galileo was startled, for that statement flatly contradicts St Robert Bellarmine's certificate of 26 May 1616, which the defendant was able to produce, and also a report of the same St Robert to the Congregation of the Holy Office, dated 3 March of the same year, in which he says that he had admonished Galileo to abandon his heliocentric views, except as a hypothesis, and that Galileo had agreed to do so. It was only in case he proved recalcitrant that he was to be given an absolute injunction by the commissary of the Inquisition. If evidence means anything, the unfortunate scientist was never summoned before the commissary in 1616, and that minute in the Vatican files remains a mystery to this day. It seems unlikely that it was forged with a view to getting Galileo into trouble later on, but it certainly does not represent the truth of what really happened. To a fair-minded reader it must seem strange that Firenzuola, who gives every appearance of acting throughout in perfect good faith, did not see the discrepancy between Bellarmine's evidence and that of the Vatican file. We must leave it at that until, if ever, some new discovery helps to solve the problem.

At the close of that first interrogation Firenzuola asked Galileo whether, when he applied for permission to print the Dialogue, he had informed the very friendly Master of the Sacred Palace, Father Riccardi, about the injunction that had been laid upon him. His answer was utterly incredible. He had not thought it necessary to inform him, 'because in that book [the Dialogue] I have neither maintained nor defended the opinion that the earth moves and that the sun is stationary, but have rather demonstrated the opposite of the Copernican view'. That ended the first interrogation, and Firenzuola must have wondered what kind of a man he was up against. Five days later, 17 April, the three experts

appointed to examine the Dialogue handed in their report. By a long list of citations they proved conclusively that Galileo had not only discussed the Copernican theory as a hypothesis, which he was entitled to do, but that he had taught, defended, and held it proved as physical fact, and had referred to those who differed from him as 'dumb idiots' and 'mental pygmies, hardly deserving the name of human beings'.

A highly competent writer who heartily detests the methods of the Inquisition, just as does any modern responsible Catholic, pronounces the following verdict on Galileo's attitude. 'The pretence that the Dialogue was written in refutation of Copernicus was so patently dishonest that his case would have been lost in any court'. Galileo was under oath to speak the truth, and at that point the cardinals of the Inquisition could fairly have charged him with perjury and so have completely broken him. But they did not want to break him, and instructed Firenzuola to see him again and endeavour to argue him out of his folly. In a letter to Cardinal Francesco Barberini, the Pope's brother, who was one of the judges at the trial and friendly towards the accused, Firenzuola was happy to report on 28 April that he had been successful: 'After many and many arguments and rejoinders had passed between us, by God's grace I obtained my object. He clearly recognized that he had gone too far and erred in his book, and he was ready to make this confession before his judges'. The unhappy genius, who was seventy and in bad health, appears to have become frightened. He even offered to add new chapters to his Dialogue in refutation of the Copernican views too freely expressed in it, 'through a vain-glorious ambition and complacency in desiring to appear more subtle than the generality of popular writers'. Alas! poor Galileo, where be your gibes now, your flashes of merriment, that were wont to set the table on a roar?

THE POPE'S HARSH DECREE AGAINST GALILEO

On 16 June the Pope ordered that a very harsh decree against Galileo be entered in the official acts of the trial. He was to be questioned under threat of torture as to his intentions in writing his book. If he maintained his views he was to be called upon to recant before a plenary session of the Holy Office; to be condemned to prison; and strictly enjoined never again to deal orally or in writing with the Copernican question. The Dialogue was to be prohibited, and that these ordinances might be generally known, copies of the sentence were to be dispatched to all apostolic nuncios and inquisitors, with particular mention of the inquisitor of Florence who must read it in full assembly, and in presence of all the local professors of mathematics. The only people to whom that decree gave satisfaction were the die-hard Aristotelians and Caccini's clique of intriguers. More thoughtful men, deeply concerned for the welfare of the Church, were appalled by it, and they included the Jesuit scientists, with the possible exception of Orazio Grassi, who had his own wounds to lick. It can nevertheless be said for the Pope that he still retained a certain tenderness for Galileo personally. Two days after the issue of his decree, he assured the Tuscan Ambassador that, though the scientist had to be shown the error of his ways, he would see to it that he 'suffered as little distress as possible', and Urban was as good as his word.

Galileo was summoned for his third and final examination on 21 June, and questioned under oath about his real convictions on the systems of Ptolemy and Copernicus. He answered that after the decree of 1616 he had always held as indisputable the position of Ptolemy, that is, the stability of the earth. Three times over he was adjured to speak his real mind, as he had shown it in his Dialogue. With the third adjuration torture was mentioned, but he still maintained that ever since 1616 he had rejected Copernicanism as an untrue theory of the heavens. The whole hearing was a pure formality, as was the threat of torture, and Galileo knew it. He lied obstinately, and his judges knew perfectly well that he was lying and perjuring himself, but they took no action of any kind on this count. He was escorted

back to his rooms, and the following day his sentence was read to him. This took place in the Great Hall of the Inquisition, on the second floor of the Dominican Convent adjoining the Minerva where, just opposite, Bernini's engaging little elephant has been so long and patiently carrying the Egyptian obelisk. The cardinals of the Holy Office were present in force and also the Dominican officials, but not the Pope. The sentence sounded much more severe than it turned out to be in practice. He was solemnly to abjure the Copernican opinion, to be imprisoned during the Holy Office's pleasure, and to recite once a week the Seven Penitential Psalms for the following three years.

HIS ABJECT ABJURATION

Then he was handed the formula of abjuration and required to recite it on his knees, though not in the customary san benito garment, the sign of infamy. He did as he was told very abjectly, and it makes one boil a little to think of so great a man being reduced to such a situation. That was the end of the whole miserable business in which the Pope himself played very little part, beyond starting it. He did not sign the sentence, and his brother Francesco and two other cardinals also refrained. The prison to which Galileo was sentenced took the shape of the Villa Medici on the Pincian Hill, whose beautiful gardens had been such a joy to him on earlier, happier occasions. He spent twelve days there, and was then permitted to leave Rome and stay at the palace of his friend Archbishop Piccolomini in Sienna. Throughout the remaining nine years of his life he remained under the jurisdiction of the Inquisition, but that body did not interfere with him very much, and soon allowed him to return to his farm at Arcetri. It even delegated to his beloved nun daughter, Suor Maria Celeste, the duty of reciting for him vicariously the Seven Penitential Psalms.

The only real penalty inflicted on the great scientist was that he had to renounce his astronomical convictions. Well qualified Catholic writers are now of opinion that the convictions were justified by the evidence at Galileo's disposal. If he held them sincerely, as everything indicates, no power on earth could compel him to renounce them, and the gravest charge against Urban VIII and the Inquisitors is that they forced a timorous old man to commit material perjury. For that it is difficult to excuse them, however well, in other respects, they treated their prisoner. Galileo would seem on moral principles to have been quite within his rights in smuggling out the Dialogue and theLetter to the Grand Duchess Christina to friends in Strasbourg, where they were published in 1635 and 1636 and circulated widely in Europe. A hundred years later, a wiser pope than Urban, Benedict XIV, permitted the Dialogue to be published and read freely by Catholics. Its author spent the years following his trial writing the book on which his universal fame as a physicist rests, the Dialogues Concerning Two New Sciences. Dynamics and Statics, which he had pursued and investigated eagerly in his Paduan days, twenty-five years earlier, and then abandoned to engage on his misguided heliocentric crusade, were at last brought to birth as sciences strictly so called. 'The crusade had ended in a fiasco; and out of the shambles modern physics was born' (Koestler). Galileo became totally blind in 1637, but continued to dictate new chapters of his great book. Milton, another famous man to go blind, visited him in 1638.

He died four years later very devoutly, with the Sacraments of the Church and the Apostolic blessing of the Pope who had condemned him. At his death-bed were many of his devoted friends and disciples, including, of course, the ever-faithful monk, Dom Benedetto Castelli. An anonymous wit wrote his epitaph, Eppur si muove, still, it [the earth] does move, famous words which he certainly did not mutter as he rose from his knees in the Great Hall of the Inquisition, nor so far as is known on any other occasion. But they go back a longer way than used to be thought, for they were discovered in 1911 on a painting ascribed to Murillo, dating no more than a decade from the time of Galileo's death. The great

old man was laid to rest in the Pantheon of the Florentines, the magnificent Franciscan Church of Santa Croce, alongside that other very contentious genius, Michelangelo. When question of a monument over his tomb arose Pope Urban told the Tuscan Ambassador that it would set a bad example, as the dead man had 'given rise to the greatest scandal throughout Christendom'. But surely the boot was on the other foot and it was Urban himself, that most sadly blundering of popes, who had given rise to the scandal by his prosecution of one of the rarest spirits in human history.

As for papal infallibility, only a person with very foolish ideas of what that precisely-worded dogma means could dream that it was involved. Not a single one of the many serious, scholarly writers who have published studies of the Galileo case, be they unbelievers, Protestants, or Catholics, has suggested it. Indeed, some of the non-Catholic scholars, for instance von Gebler, go out of their way to prove that papal infallibility was in no way implicated.

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