Reconstructing Nature

The Engagement of Science and Religion

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The Contemporary Relevance of the Galileo Affair

The scene is a piazza in Florence. Two drunks enter and confront the statue of a great scientist. In their inebriated state they find it impossible to articulate a name as testing as Galileo Galilei. 'What's he famous for?' asks the one. 'Wasn't it he who proved the earth spins?' comes the reply. 'Hic ... a colleague then' splutters the first.

Another monument, this time in Rome, stands as a reminder that a spinning earth was a terribly sober matter. The inscription on a column adjacent to the Villa Medici reads: 'It was here that Galileo was kept prisoner by the Holy Office, being guilty of having seen that the earth moves around the sun.'[1] Now it is true that Galileo, through his telescope, had seen many new things in the heavens, the moons of Jupiter for example and the phases of Venus; but one thing he had not seen – in the common meaning of 'see' – was the earth moving around the sun. He saw what everybody saw: the sun moving across the sky. In another sense of 'see', that of grasping or understanding, the inscription may be less misleading; but it still carries a barbed message. The implication seems to be that Galileo was condemned for having seen the truth.

This simple message lies at the centre of what one might call the popular mythology of the Galileo affair. His forced recantation in June 1633 has been a potent, perhaps the most potent, symbol of the suppression of truth in the name of religion. When the actor Richard Griffiths, who had been playing the part of Galileo in Brecht's play, was asked to review a recent biography, he delivered the lines that have become all too familiar: 'By stifling the truth, which was there for anyone to see, the Church destroyed its credibility with science.'[2] Note the investment again in that powerful verb to 'see'. By contrast with the modern actor, the historian is obliged to ask whether the 'truth' was so transparent, whether Galileo's problems did not arise in part because he was trying to demonstrate motions of the earth

that were *invisible*.[3] In this chapter we take a fresh look at the events surrounding Galileo's trial. Every generation re-examines the issues, placing its own construction on events and signalling the lessons that can be learned from them. Our own age is no exception. In recent years the Vatican itself has given the newspapers a field day. One has read headlines to the effect that 'Vatican admits Galileo was right all along', as if it is only in the 1990s that the Catholic Church has woken up to the fact that the earth is a planet.

Under such circumstances, arguments for the value of historical enquiry are not difficult to find. For example, we might ask how the Catholic Church sought to exonerate itself in the past and how far the admission of error is a recent phenomenon. Without a knowledge of the issues as they were perceived at the time, how can we begin to evaluate the rather bland remark of Pope John Paul[4] that 'in this affair the agreements between religion and science are more numerous and above all more important than the incomprehensions'? Such a remark may raise the deeper and more disturbing question: who controls the histories that have been constructed and reconstructed, whether in the service of the Catholic Church or in the interests of scientific humanism? Can an impartial history be written, or a consensus achieved, when the issues may still carry an emotional charge?

Inherent Conflict between Science and Religion – An A-historical Mould

There is a way of writing about the Galileo affair that has popular appeal but which has the effect of removing the need for serious historical enquiry. It could be described as fitting the history into an a-historical mould. The mould is shaped by the assumption that there is an inherent conflict between 'science' and 'religion', arising from competing sources of authority, competing methodologies, or competing criteria for truth. This view, that there is something essential to science and something essential to religion that keeps them perpetually at war, provides a ready-made interpretation of Galileo's misfortune. His trial is simply seen as the kind of event one would expect when a persecuting Church encountered a troublesome scientific innovator. It is a seductive interpretation because, scanning the events that led to the trial, it is easy enough to pick out those features which at first sight fit the picture.

There were, for example, genuine difficulties raised by the Copernican system, which the Church authorities could not

disregard.[5] It violated the Aristotelian dichotomy between the corrupt sublunar and the perfect superlunary regions of the cosmos. It posed a dilemma concerning the status of humanity in the universe. There was a sense in which it elevated humankind by placing us in the heavenly region among the planets. But there was also a sense in which we were downgraded, wrenched from the centre of the cosmos. The telescopic observations for which Galileo became famous challenged the perfection of the heavens: there were mountains on the moon and spots on the sun.[6] There was also a formidable epistemological issue: whether through the practice of mathematical astronomy one could presume to construct a physical model that revealed the true geography of the cosmos. When the Lutheran Andreas Osiander had composed his anonymous *Preface* to Copernicus's great book of 1543, he had advised his readers not to be perturbed by the heliostatic proposal, for it was nothing more than a mathematical model.[7] Galileo believed otherwise.

If we are looking for sources of conflict they are not difficult to find. The authority of Scripture was undoubtedly an issue. Joshua's command to the sun to stand still was not a little curious if the sun were already at rest.[8] That the earth had become a planet opened up other possibilities. Perhaps other planets were inhabited? Perhaps, as Giordano Bruno had argued, there was an infinite plurality of worlds?[9] Where would we be then, bereft of our cosmic identity?[10] When Galileo compared the appearance of the moon's surface to that of Bohemia, he was quickly warned by his friend Giovanni Ciampoli to withdraw the comparison. Otherwise trouble-makers would soon be asking how descendants of Adam and Eve could possibly have got up there.[11]

The temptation to speak of warfare between religion and science may become even greater when we look at the behaviour of Galileo and his adversaries. There *were* ignorant priests among his detractors. One Niccolo Lorini vouchsafed to Galileo that 'the opinion of *Ipernicus* ... appears to be against Holy Scripture'.[12] Another Dominican, Tommaso Caccini, declared from his pulpit that all mathematicians were magicians and enemies of the faith. 'You can see how and by whom poor philosophy suffers', wrote Galileo to Prince Cesi, the founder of the scientific academy to which he belonged.[13] Galileo's own belligerent language is also too good to miss. He complained that his opponents were incapable of following the simplest argument and he wrote as if he had a patent on any discovery made in the heavens. In his slanging match with the Jesuit mathematician Horatio Grassi he pushed the display of satire to its limits. In a challenge to Galileo's ideas on the nature of heat, Grassi

had observed that the Babylonians had cooked their eggs by whirling them in slings. Galileo's riposte was enough to make a Pope laugh:

> If Sarsi wants me to believe ... that the Babylonians cooked eggs by whirling them rapidly in slings, I shall do so; but I must say that the cause of this effect is very far from that which he attributes to it. To discover the truth I shall reason thus: 'If we do not achieve an effect which others formerly achieved, it must be that in our operations we lack something which was the cause of this effect succeeding, and if we lack but one single thing, then this alone can be the cause. Now we do not lack eggs, or slings, or sturdy fellows to whirl them; and still they do not cook, but rather they cool down faster if hot. And since nothing is lacking to us except being Babylonians, then being Babylonians is the cause of the eggs hardening'. And this is what I wished to determine.[14]

By a selective reading of the evidence the model of inherent 'conflict between science and religion' can begin to look plausible as an account of what lay behind the trial. But this is to squeeze events into a preconceived mould.[15] With the intervention of the historian the story does not simply become fuller. It takes on twists and turns that are sometimes surprising. And as they may break the mould of our expectations, so they may have a contemporary relevance. There are complications that are both fascinating and instructive.

Breaking the Mould: Some Historical Complications

One of the most enthralling aspects of the Galileo story concerns his relationship with Pope Urban VIII, which initially had been one of friendship. Even during the difficult year 1616 when the motion of the earth was prohibited, Maffeo Barberini, as he then was, did his best to reassure Galileo that as long as he spoke as a mathematician and avoided theological matters he would have nothing to fear. Although the consultants used by Cardinal Bellarmine reported that a central immobile sun was formally heretical, the official pronouncement by the Congregation of the Index did not employ the word 'heresy'.[16] There is evidence from a letter to Campanella, written many years later in 1630, that Barberini's presence may have been behind that deletion. In the letter Barberini implied that he had not even approved the weaker terms of the prohibition: 'It was never our intention [to prohibit Copernicus]; and if [it] had been left to us, that decree ... would not have been made'.[17] Galileo and his friends were elated when the cultured cardinal became Pope.

Mario Biagioli has recently written that 'Urban was a sophisticated courtier, humanist, and poet, not a scholastic theologian. He was a courtier-pope (and that it is why he appreciated Galileo so much).'[18]

Our earlier quip that Galileo's dismissal of the Jesuit Grassi was enough to make a Pope laugh was not a throwaway line. Galileo's *Assayer* (1623) had been dedicated to Barberini and it is known that parts of it were read aloud to him. Not only did he chortle while he dined; he was particularly impressed by a fable, told by Galileo, about a man who tried to discover the origin of a certain sound. Each time the man thought he had found the cause he heard the same sound again produced in some other way. In a crucial experiment on a cicada to solve the riddle once and for all, the man had pierced the poor creature's ligaments so severely that he had accidentally silenced *it*. It has been suggested that one reason why Barberini loved the story was that it resonated with his own conviction that the fun of scientific debate consisted in the cut and thrust of the duel, not in reaching closure and a definitive answer.[19]

The crucial point is that we are not dealing with a straightforward case of 'religion versus science'. Barberini had even written an adulatory poem in which the pursuit of astronomy was a moral and glorious enterprise.[20] Consequently the historian's question becomes, 'What went wrong with this relationship of mutual respect?' No general model of '*the* relations between science and religion' can possibly capture the nuances of such a change. Part of the explanation would seem to be that in his *Dialogue Concerning the Two Chief World Systems* (1632) Galileo mishandled an official instruction. He had been instructed to include the Pope's argument that definitive conclusions could not be reached in the natural sciences. God in his omnipotence could produce a natural phenomenon in any number of ways and it was therefore presumptuous for any philosopher to claim that he had determined a unique solution.[21] It was surely possible that the tides were produced by some mechanism quite other than by the earth's compound motions. Galileo did include the argument but he placed it in the mouth of Simplicio, often the dullard in the *Dialogue*.[22] As a defender of Aristotelian common sense Simplicio had been corrected time and again. Urban was not amused.[23] It would be easy to claim that a friendship had been betrayed, though it is difficult to believe this was Galileo's intention.[24]

A second complication concerns the origins of animosity towards Galileo. On the basis of the simple conflict model, one would expect his enemies to be powerful figures in the Church. Galileo, however, did not see it that way – at least initially. His *Letter to the Grand Duchess*

Christina, which dates from 1615, began with a quite different complaint. It was that academic professors were stirring up trouble for him and were trying to inveigle the Church authorities into denouncing him.[25] Here the crucial point is that Galileo made academic enemies because his scientific innovations were a threat to Aristotelian principles. On such matters as floating bodies, falling bodies, and imperfection in the heavens he was contravening an established science of nature. Because the Catholic Church had a heavy investment in Aristotelian philosophy, the conflict was not a simple one between 'science' and 'religion'. It was rather between new science and the science sanctified by previous generations. Such complications in fact make it extremely difficult to use words such as 'science' and 'religion' when reconstructing the issues. It has been said, for example, that Galileo perceived the Aristotelian professors as if they were members of a religious order.[26] The point could perhaps be made this way. Whereas those who revered the authority of Aristotle in natural philosophy were bound to oppose Galileo's innovations, the question for churchmen who took an interest in nature was how far their Church was bound to protect Aristotelian principles. When Galileo asked whether the affirmation of change in the heavens was admissible, Cardinal Carlo Conti replied that the Bible did not support Aristotle. The common opinion of the Fathers, contrary to Aristotle, had been that the heavens are corruptible.[27]

Between 1610 and 1620 there was even movement among the Jesuits away from Aristotelian dogma. Cardinal Bellarmine, who had to break the news to Galileo in 1616 that he was no longer free to promote the Copernican system, nevertheless accepted the argument that Scripture did not favour the immutability of the heavens.[28] In conceding that fresh consideration might have to be given to certain biblical texts, were the motion of the earth to be demonstrated, Bellarmine also diverged from what has been seen as the standard Dominican position – that astronomical hypotheses were mathematical models only and in principle untranslatable into physical truths.[29] The Jesuit Grassi, with whom Galileo quarrelled, was prepared to abandon Aristotle's notion that comets were sublunar phenomena.[30] There was even a willingness among Jesuit astronomers to embrace the system of the Protestant Tycho Brahe. This was an ingenious model, conservative in that the earth remained stationary at the centre, but also radical in that all the planets were allowed to orbit the sun. Necessarily on this view, the sun orbited the earth, carrying the planets with it.[31] To Galileo this was a cumbersome compromise, but it was difficult to disprove. It is worth stressing again that we are dealing here not with competition

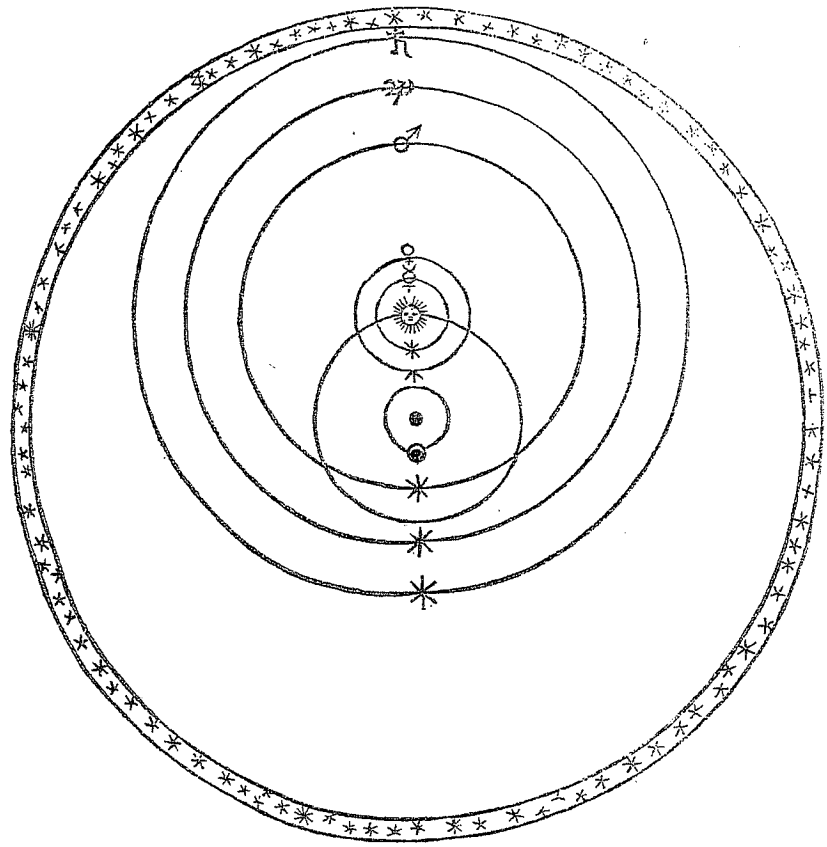

Figure 13: The earth-centred system of Tycho Brahe with the planets circling the sun. From *De Mundi Aetherei Recentioribus Phaenomenis*, in *Opera Omnia* (1648).

between 'science' and 'religion' , but with competing scientific models that can also be differentiated in terms of their respective theological appeal.

Divisions of opinion within the Catholic Church constitute a third complication. In popular writing on science and religion, 'the Church' is often presented as a monolithic institution with a non-negotiable set of beliefs. But when the Copernican system was placed under review in 1615–16, it was partly because Bellarmine was genuinely uncertain about the kind of response that was required. We have already seen that the future Pope, Maffeo Barberini, took a different view from those whom Bellarmine consulted. And whilst

the discussion was underway, the Dominican Tommaso Campanella developed forceful arguments which, had they been accepted, would have left Galileo free to continue his Copernican rhetoric.[32] That there could be real divisions over strategy becomes perfectly clear from Campanella's warning about the consequences if his Church were to condemn the Copernican system. Rather like Galileo himself, he warned that if the new astronomy were vindicated it would 'bring upon our Roman faith no small mockery in the eyes of heretics, for all [Galileo's] doctrine and the telescope have found avid acceptance in Germany, France, England, Poland and Sweden'.[33] Doctrinal divisions and political jealousies between Dominicans and Jesuits were also part of the complex. Their interminable controversy over divine grace and free will combined with the Jesuits' commitment to an education in the physical sciences had produced a situation in which Galileo and the Jesuit astronomer Christopher Scheiner were to become enemies because they had so much in common.[34] In one of the most original recent studies, Galileo's downfall is ascribed to his pushing the Jesuits one step too far, asking them to accept too much without the requisite proof. According to Rivka Feldhay we have to recognise a 'triple struggle for cultural hegemony' within the Church, the science of Galileo upsetting a precarious balance and polarising existing forces.[35] It is the disparity of views among those who became embroiled in the Galileo affair that makes historical research so rewarding. A further illustration comes from the period leading up to the trial when Galileo's friend Benedetto Castelli reported an exchange with Vincenzo Maculano, the Commissary of the Holy Office. Castelli's report is particularly pertinent because Maculano was eventually to be Galileo's interrogator. According to Castelli, Maculano had said that he personally did not believe that the matter of the earth's motion could be decided by the authority of Scripture and that he wanted to write on the subject himself. Galileo's interrogator may have been more sympathetic to his plight than external formalities allowed.[36]

This brings us to our fourth complication: the authority of Scripture and how it should be constituted. The issue arises because, as Galileo himself had pointed out, a flat appeal to the Bible simply glossed over the fact that everything hinged on how it was to be interpreted. Only his crudest opponents, such as Lodovico delle Colombe, had adopted the principle that 'when Scripture can be understood literally, it ought never be interpreted differently'.[37] Colombe claimed that all theologians, without exception, adopted this view. Yet Galileo could retaliate that, on the contrary, it was the principle of biblical accommodation that was 'so commonplace and

so definite among all theologians that it would be superfluous to present any testimony for it'.[38]

The crucial contrast, however, is not between Galileo and Colombe but between Galileo and Bellarmine. It was Bellarmine who had to clarify the official position in 1615 in response to the work of Paolo Foscarini who had published a text in which the earth's motion was shown to be compatible with Scripture. Bellarmine's reply to Foscarini is one of the most fascinating documents in the whole affair. As we indicated in chapter 1 there is one paragraph in his letter that almost suggests he was more liberal on biblical exegesis than Galileo himself. Bellarmine wrote, 'that if there were a true demonstration that the sun is at the centre of the world and the earth in the third heaven ... then one would have to proceed with great care in explaining the Scriptures that appear contrary, and say rather that we do not understand them than that what is demonstrated is false'.[39]

This seems a long way from the view that Galileo was condemned because he had seen the truth. Superficially at least, Bellarmine seems to be allowing room for manoeuvre. But there was also a reactionary note in Bellarmine's letter, illustrating a point that historians feel obliged to underline. When it comes to the defence of authority, several different argumentative strategies may be more attractive than one, even though they may not all cohere. If there is inconsistency between them, it may also indicate uncertainty about how to proceed.

Arguably, Galileo himself was inconsistent on the extent to which Scripture had jurisdiction over science. Invoking the authority of St Augustine, he had contrasted propositions that were rigorously demonstrated with those that were not. As to the former, the onus was on wise divines to show that they did not contradict the Bible, but the latter were to be rejected if they contravened Scripture.[40] We can see in retrospect that problems arose because the Copernican theory was still being developed and did not properly fit into either of Galileo's categories.[41] The inconsistency in his position concerns the implication that Scripture retains its jurisdiction over undemonstrated propositions whereas he had earlier said that biblical language had been 'accommodated' to the needs of simple folk and was not to be confused with the technical vocabulary of the natural philosopher.[42] If undemonstrated propositions that clashed with Scripture were to be held 'undoubtedly false', Galileo could be regarded as having undermined his own position.[43]

It was, however, an inconsistency in Bellarmine's position that was to prove the more dangerous. Although he appeared to leave the

door open for reinterpretation in the event of a rigorous proof, that possibility was not seriously entertained. The door had, in effect, already been shut. Bellarmine had locked it by referring to the Council of Trent's ruling that where there was agreement among the Fathers on the exegesis of a particular text, that consensus had to be respected. And their consensus had in fact been in favour of a literal interpretation of the ostensibly geostatic verses.[44] Galileo had two counter arguments. One was that the Fathers could not have come to a deliberate conclusion because they had written long before it had become, with Copernicus, a real issue. The other was that physical propositions should be distinguished from matters of faith – a contention famously expressed in the aphorism that the Bible teaches how to go to heaven, not how heaven goes.[45] But he was in for a shock when Bellarmine gave a new twist to what might be meant by a matter of faith. In Bellarmine's letter to Foscarini there was a stern warning that the issue after all was a matter of faith. It might not be 'as regards the topic' but it was 'as regards the speaker'.[46] In the last analysis it was the Holy Spirit who had spoken and who could not be gainsaid. The tragedy is that, in placing his own gloss on the Tridentine decree, Bellarmine extended the domain of truths to be believed on the basis of faith. There was a sense in which the category of 'faith and morals' was now all-embracing.[47] In the long run the Catholic Church had to abandon that hard, undiscriminating line. The irony is that *Galileo*'s principles of exegesis are now declared by the Vatican to have been in the best traditions of his Church.[48]

If the theology is to be contextualised, so must the science be. Just how convincing were Galileo's proofs of the earth's motion? This is a difficult question and a further complication because what is convincing to one scholar may not be to another. What is clear is that the situation was far more complex than would be implied by the popular antithesis between truth and error. Galileo had powerful arguments against Aristotelian philosophy and against a traditional cosmography. Mountains on the moon and spots on the sun told against the perfection of the heavens. The observed phases of Venus were only possible if that planet at least were in orbit around the sun. Even on such straightforward matters, however, the case had not been without its problems. Suppose the dark spots were not on the sun's surface but the shadows cast by satellites in orbit around it? That suggestion was made by Christopher Scheiner, who buttressed his case by pointing out that to postulate satellites around the sun was perfectly in keeping with Galileo's own discovery of satellites around Jupiter![49] There was of course a logical problem too. To remove objections to the earth's motion is one thing, but it is not the

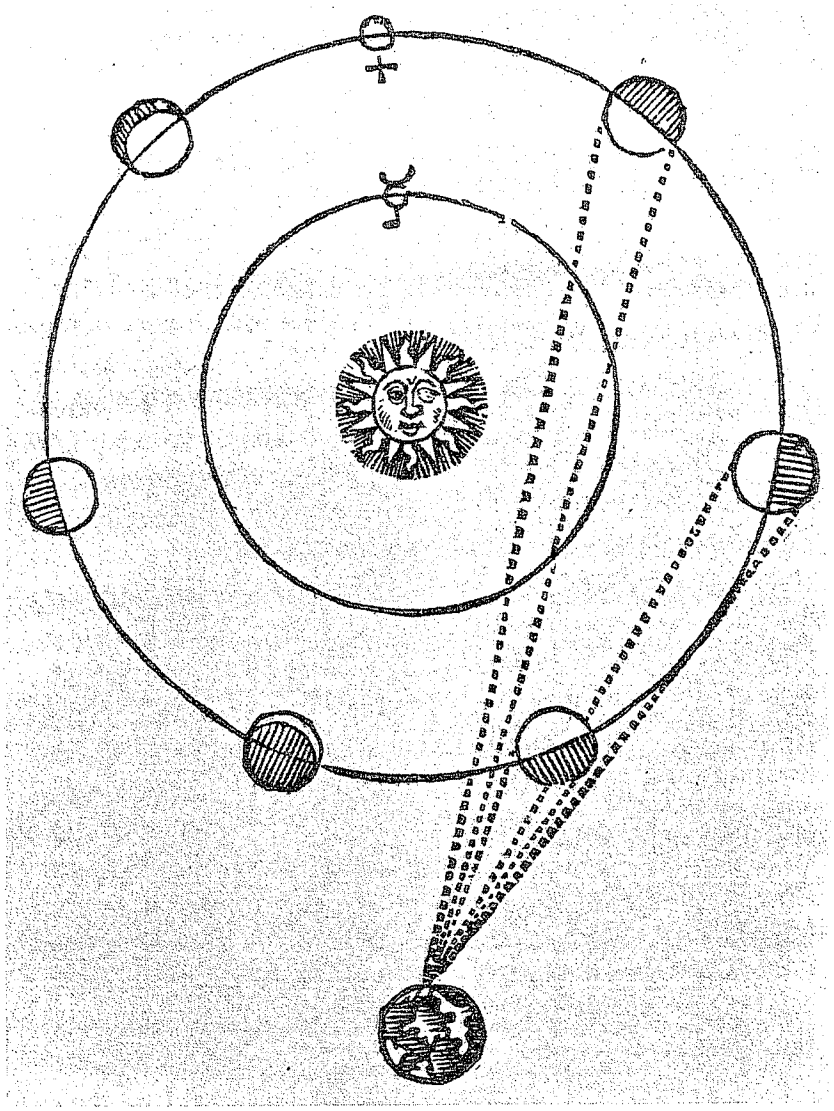

Figure 14: The phases of Venus become explicable if Venus orbits the sun. From Pierre Gassendi, *Institutio Astronomica* (1653).

same as proving that it moves. Had there been only two chief world systems, the Ptolemaic and the Copernican, to disprove the one would have been to establish the other. Galileo himself saw all the advantages of presenting the case that way. But there were other

options, notably the system of Tycho Brahe to which we have referred, in which all the planets but not the earth orbited the sun, and the sun continued to circle a stationary earth. Not a single one of the telescopic observations refuted it. How then were the earth's invisible motions to be demonstrated?

One of Galileo's tactics was to argue indirectly by analogy. From the changing pattern of the sunspots he inferred that the sun must be rotating, lending plausibility to the case for a rotating earth. Such arguments, however compelling, were not conclusive. He obviously needed a trump card. But in the game he was playing it was easy to over-reach himself. And brilliant philosopher though he was, he was not infallible.

His confidence was placed in an argument from the tides. His readers were to imagine a Venetian barge carrying water. When the barge hit the side of the quay, the sudden impact would set up an oscillation in the water. The phenomenon of the tides is one in which there is similar oscillation of the seas. It could therefore be produced if the earth were subject to a comparable jolt or regular series of jolts. And because the earth has both its axial and orbital revolutions, points on its surface will experience such an effect. Judged against an appropriate frame of reference there would be changes in their absolute speed, arising from a combination of motions that partially reinforced each other but which, for part of every day, did not. Thus were the tidal motions produced.

It is now generally agreed that Galileo over-reached himself scientifically because within the frames of reference defined by the earth's motions such an effect would not be experienced. By giving this argument prominence in the *Dialogue*, he also over-reached himself diplomatically. Urban VIII had not liked the argument because it unequivocally transposed the Copernican hypothesis into a physical and not merely a mathematical conception.[50] Moreover, a proper respect for the omnipotence of God required the concession that other mechanisms might have been created to produce the tides. The upshot of all this has been correctly conveyed by Maurice Finocchiaro when he writes:

> We are dealing with nonapodictic arguments which are not completely conclusive but rather susceptible of degrees of rational correctness, and so it is entirely conceivable that there should sometimes be equally good arguments in support of opposite sides, as well as that the arguments for one side should be better than those for the opposite, without the latter being worthless.[51]

Once this is acknowledged there can be no black and white treatment of the Galileo affair. There is, however, a residual irony. Galileo was not condemned in 1633 because he had failed to produce adequate proof. His crime was to have presented his proofs in such a way that they were made to appear strong and effective. It was this that convinced the team of investigators that he had overstepped the mark in positively promoting the Copernican system when he had been forbidden to do so.[52]

Historical Context

We have been suggesting that, for the historian, events no longer fall into the simple mould of 'science versus religion' or 'religion versus science'. Even among Galileo's detractors, such as Caccini, it was acknowledged that he was widely regarded as a loyal Catholic.[53] To place the Galileo affair in context means placing it in the context of Counter-Reformation culture. At its most theological, this meant a working out of the principle that authority was not to be vested in Scripture alone, as Protestant reformers demanded, but in tradition as well. As Melchior Cano, one of the founders of post-Tridentine theology, insisted, tradition had preceded the Scriptures in the early history of the Church and arguably contained the greater part of revelation.[54] In his influential work *De Locis Theologicis* (1563), Cano had recognised that 'when the authority of the saints ... pertains to the faculties contained within the natural light of reason, it does not provide certain arguments but only arguments as strong as reason itself when in agreement with nature'.[55] That could have provided just the space that Galileo required. But when speaking of the exposition of Scripture, Cano had declared that 'the common interpretation of all the old saints provides the theologian with a most certain argument for the corroboration of theological assertions; for indeed the meaning of the Holy Spirit is the same as the meaning of all of the saints'. As if that were not enough he had added that 'all the saints taken together cannot err on dogmas of the faith'.[56] This was the message Bellarmine preferred and which he delivered back to Foscarini. Why? It is difficult not to see the effect of a life-time's engagement with Protestant heretics – an engagement that had led to a creeping rigidity on both sides.[57] Bellarmine had also presided over the trial of Giordano Bruno whose extension of Copernican ideas to embrace an infinite plurality of worlds was only one heresy among many.[58] It had been rumoured at the time that Bruno had declared Christ a rogue who got what he deserved, that all monks were asses, and Catholic doctrines asinine. In the long

struggle to control heresy both within and without his Church, Bellarmine was inexorably driven towards his reactionary stance. Galileo did not fight shy of interpreting Scripture for himself. He even suggested that the miracle of the long day of Joshua was more comprehensible on the Copernican than the Ptolemaic system.[59] It would not have been difficult to perceive Galileo as a crypto-Protestant, tarred with the same brush as his friend Paolo Sarpi who had led a Venetian revolt against the papacy.[60]

The impact of Protestant–Catholic dialectics on Galileo's fate may have been indirect but it was real enough.[61] Urban VIII had had his own concerns about protecting the faithful. The problem was the loss of authorial control. New ideas in cosmology, even if presented by loyal members of the Church, were liable to have more dangerous and dissident ideas read into them: 'One man amplifies, the next one alters, and what came from the author's own mouth becomes so transformed in spreading that he will no longer recognize it as his own.'[62] By contrast Galileo implied that one of his reasons for publishing his *Dialogue* was that it would prove a good Catholic could be at the forefront of astronomical thinking.

Despite his qualms, as late as 1630 Urban still believed that the ban of 1616 had been too severe.[63] Why then was he so severe on Galileo? He was evidently insulted by the *Dialogue*, but was he working under other pressures that might have provoked an over-reaction? As part of the context in which the dénouement occurred, at least two such pressures have been identified. One came from Spain through complaints that the Roman Inquisition was being too soft on dissidents.[64] The other, with which it was connected, arose from Urban VIII's foreign policy during the Thirty Years War.

Having sided with France to prevent a Hapsburg hegemony, he found himself in an exposed position when Louis XIII agreed to an alliance with the Protestant Gustavus Adolphus of Sweden. Gustavus was enjoying military success against the German Empire and so it appeared that Urban was betraying the Catholic cause.[65] This compounded the criticism from Spain, which was voiced in a dramatic manner on 8 March 1632. At a meeting of the consistory, Cardinal Borgia, who represented the Spanish interest, read out a harsh protest at Urban's failure to support the Spanish campaign against Protestants in Germany. There was even the insinuation that a Council was needed to assess the Pope's will to defend Christianity. Urban and his nephew tried to silence the man but unsuccessfully. Urban's brother was moved to grab him but was stopped in his tracks. Eventually the guards were called in to control the unrest. Cardinals, we are told, broke their glasses and tore their hats.[66]

Having failed to protect himself against charges of nepotism, Urban VIII clearly had enough worries without having to consider whether the earth was moving under his feet. His treatment of Galileo has been seen, not surprisingly, as part of a determination to reassert his authority. A nervous Pope, having his horoscope read and fearing poison, was not perhaps the most balanced judge of Galileo's machinations, or his loyalty.[67]

Galileo himself needed an explanation of the Pope's disaffection. He found it in the conjecture that Urban had been got at by the Jesuits.[68] Was he right? Or was this self-delusion? Either way his relations with the Jesuit Order become an aspect of the context that cannot be ignored. It is certainly tempting to implicate the Jesuits with whom Galileo had fallen out. Christopher Scheiner was in Rome at the time of the trial and still smarting from the controversy over sunspots in which Galileo, so he believed, had cheated him of priority. Scheiner's flattering description of his adversary was of an impudent usurper.[69] The evidence for estrangement is certainly there. One of the ironies is that the ban on the Copernican system issued in 1616 created a situation in which, even if Galileo had got a decisive proof of the earth's motion, he was not allowed to publish it. The Jesuits were aware of this and displayed the kind of anxiety that comes from wondering whether Galileo, after all, knew something they did not. The quarrel with Grassi over the nature of comets undoubtedly created an atmosphere in which Galileo and the Jesuits became locked in an intellectual trial of strength. Any vestige of friendship Grassi might have retained was to disappear when he saw a letter from Florence claiming that the Jesuits would be powerless to answer Galileo's arguments. Grassi's reported reaction was that if his Order could answer a hundred heretics a year, they would not be beaten by one Catholic.[70]

At this point we should remember that Urban VIII had not vetoed discussion of the Copernican system as a mathematical hypothesis, but he had precluded its presentation as a physical reality. A deeper exploration of the context becomes necessary here because an ambiguity in what might be meant by a scientific hypothesis arguably created scope for misunderstanding. The importance of the distinction has been brought out by saying that it could be a more radical position to interpret the Copernican system as a physical hypothesis and *reject* it, than to interpret it in the purely mathematical sense and to *accept* it. It could be accepted as an instrument facilitating the prediction of planetary positions without transgressing a traditional hierarchy of the sciences in which mathematical astronomy could not dictate terms to physics.[71] The conservative position on this

matter had been expressed by the Dominican theologian Giovanni Tolosani when he had judged the Copernican system to be heretical. Revealingly he castigated Copernicus for mixing the disciplinary realms of physics and astronomy.[72]

It would be misleading to suggest that within the Catholic Church there had been no movement towards a *physical* astronomy. Before his death in 1612, the Jesuit astronomer Christopher Clavius had already rejected a purely instrumentalist approach to astronomical theory.[73] This means that even within the Church there was the possibility of misunderstanding when reference was made to astronomical hypotheses. There is evidence, too, that the very possibility of a shift towards a physical astronomy was dividing Jesuits and Dominicans around 1615–1616 when the Copernican hypothesis was subject to scrutiny.[74] Misunderstanding actually arose because Galileo was so often told that he should treat the Copernican system only as a supposition. To him this might have meant that he was allowed to discuss it as a provisional truth-claim, as long as the emphasis was on the provisional. But the instruction to confine himself to a hypothetical discussion might have been intended quite differently: that he should remain within the bounds of a mathematical model that had no pretensions to physical representation.

It was, therefore, possible for Galileo and Urban VIII to talk past each other and for each to be unpleasantly surprised by the eventual moves of the other.[75] Divergences of perception were accentuated because those who mediated between Galileo and Urban tended to be selective in what they communicated. In either direction the diplomacy could leave both men deceived. It was only parts of Galileo's *Assayer*, notably the 'fable of sound', that Urban had had read to him. Likewise with another of Galileo's productions, his *Letter to Ingoli*. This had been written in the summer of 1624 and was construed by Galileo's friends as an explicit defence of Copernicus. It was eventually read to Urban by Ciampoli who reported back to Galileo a favourable reaction. But as Fantoli shrewdly observes, 'it is probable that Ciampoli chose with dexterity those passages where there was no risk of offending the susceptibility of the Pope'.[76] We can therefore understand how it was possible for relations to remain cordial until the storm broke over the *Dialogue*.[77] According to the Tuscan ambassador, Niccolini, what really irked the Pope was that 'when asking Ciampoli many times what was happening with Galileo, His Holiness had never been told anything but good and had never been given the news that the book was being printed, even when he was beginning to smell something'.[78] Urban was incensed because he

saw a mixture of deception and betrayal in the promotion of a physical doctrine already condemned.

The Uses of History

We have been suggesting that a richer understanding of the Galileo affair can be gained if we refrain from squeezing it into a preconceived mould. It is also instructive to see how the story has been used in subsequent historical contexts. As a deeply symbolic episode in the cultural history of Europe it has been endlessly reconstructed to satisfy new needs and to support new agendas. So many different images of Galileo have been constructed that one scholar has wryly referred to a 'trial of Galileos'.[79]

An obvious place to start would be with the early histories written by Roman Catholic scholars in the defence and exoneration of their Church. Their writing was all the more urgent because there was undoubtedly a current of opinion within Catholic Europe that Galileo had been unjustly treated.[80] It could always be argued that through his disobedience he had been responsible for his own downfall. One could point to his impetuosity, to the scorn he arrogantly poured on others. It was not difficult to paint a picture in which he had tried to foist the Copernican system on his Church before he had decisive proof. Within what we might call a conservative Catholic historiography, it would be taken for granted that the Church has a moral right to discipline its members. The immorality could always be imputed to Galileo who, at his trial in 1633, had denied what was manifestly true – that he had championed, in print, the moving earth.[81]

There were many variations on these themes. In attacks on the cogency of Galileo's science, it would sometimes be said that his proof from the tides was misconceived. With even more ingenuity, unfavourable contrasts would later be drawn between Galileo and Kepler. The trick here was to say that the Copernican theory, as defended by Galileo, was in fact false. Galileo had continued to regard a circular motion for the planets as natural, despite Kepler's proof that they moved in ellipses. Taking the system as a whole, Galileo was wrong. Because of this, the Church might be excused for stamping on inferior science! The arguments were not always that devious, but there would usually be reference to the inconclusiveness of the scientific evidence at the time.

It is striking that when the Church's position eventually changed in the early 1820s, the history of science gained a peculiar

significance. Guiseppe Settele, a professor of astronomy at the University of Rome, was given permission by the Commissary of the Holy Office to present the Copernican system as fact rather than hypothesis, but only on the condition that he showed his readers that the scientific difficulties with which the system had once been beset were no longer cogent.[82] This shift had at least two consequences. By 1835, Copernican books, including Galileo's *Dialogue*, were removed from the Index. And henceforward Catholic scientists could cite the Galileo affair as a warning of what would happen again if a scientific doctrine that might ultimately prevail were outlawed. As we shall see in chapter 8, the Catholic evolutionist St George Mivart would present himself as a latter-day Galileo when his relations with Rome deteriorated in the closing decades of the nineteenth century.

New histories often reflect new historical circumstances. We can perhaps best appreciate this from recent events. Why did Pope John Paul II choose to encourage new historical initiatives? One answer that *he* gave was to help avoid similar mistakes in the future. It was recognised that the Church had burdened itself with an image of repression that elicits scorn from those who value the autonomy of the sciences. As others have observed, it can hardly be coincidence that a Polish pope should take so distinctive an interest in the treatment accorded the theory of a Polish astronomer. But if there has been a re-writing of history and a frank admission of error, it is not the end of the story. One recent biographer of Galileo, James Reston, remains disillusioned. Having asked why the latest official statements contain no specific criticism of Pope Urban VIII, he was told that this was because the Commission's study was about events not personalities. As the author of a lively study of the personalities involved, Reston found this reply lame. To be told that the errors had been made by Galileo's judges, not by Urban VIII, was a hard pill to swallow if one believed that Urban had been involved in the orchestration of events.[83] In the eyes of a Catholic biographer of Galileo there is still unfinished business.[84]

What of the alternative historiographical traditions in which Galileo has been the hero, the scientific genius, the brilliant empiricist who unequivocally had the truth on his side? From his trial and tribulation messages of contemporary relevance have been repeatedly drawn. His first biographer, Vincenzio Viviani, launched the heroic Galileo. Although Galileo's date of birth is usually given as 15 February 1564, Viviani wanted it to be 18 February because it would then be the same day on which Michelangelo had died. Florence could then boast its unbroken succession of genius. As Michelangelo had been made the patron-saint of the artists, so Galileo might

become the same for the mathematical philosophers.[85] It had been the fashion in Renaissance biography to project an image of the artist as a child prodigy, gifted with an almost supernatural knowledge of nature. An artist's date of birth would assume the highest significance, as if a god were being born. To conform to literary taste a little 'image enhancement' was the order of the day.[86] Viviani, writing in Italian for a cultured audience, duly obliged. Galileo was the child prodigy who had been self-taught, had read his first Latin authors at a tender age, had learned Greek, mastered the lute and shown exceptional promise as a painter. For an audience that would appreciate the force of visual demonstration more than mathematics, Viviani gave them Galileo the shrewd observer, the acute experimenter. He was only nineteen, according to Viviani, when he inferred the principle of the pendulum from a swinging lamp in Pisa cathedral. And he was still a young man when he spectacularly refuted Aristotle on falling bodies. Did the rate of fall depend on the weight of the object, as Aristotle had taught? Such a view could not withstand the simple test of experiment. Ostentatiously dropping different weights from the leaning tower of Pisa, Galileo showed they hit the ground simultaneously. Viviani even spoke of 'repeated experiments in the presence of other lecturers and philosophers and all the student body'.[87]

There is only one problem with these towering images. They are almost certainly untrue. The swinging lamp that so transfixed Galileo was not itself fixed in the cathedral until four years after the date assigned by Viviani. As for the constant frequency of the pendulum swing, this was not mentioned by Galileo himself until some fifteen years later. The story of the leaning tower became so embellished in later accounts that some wit once calculated that if Galileo had really dropped the massive weights ascribed to him, they would have sunk so far into the foundations that he and the tower would have crumbled to the ground. The evidence suggests that at the time he was allegedly conducting his experiment Galileo still believed that objects made from different materials would fall at different rates. And what he actually reported was an even more curious result – that when balls of lead and wood were released simultaneously, the wood got off to a flying start, only to be overtaken by the lead in due course.[88] One of the most heroic images of Galileo is at the very least distorted.

Viviani was associated with the Tuscan court throughout his life. In Galileo's declining years, he had become his amanuensis. The brief life that he composed reflected the biographical style of his day and a desire to defend his master's reputation. Not everyone of his

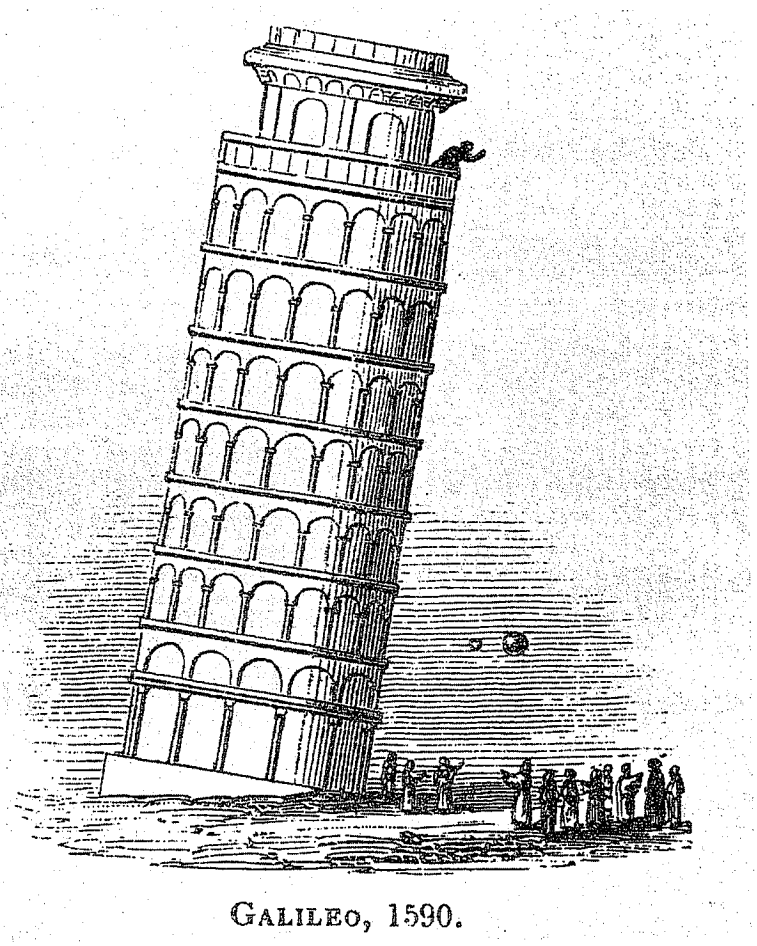

Figure 15: The depiction of a famous myth. From Baden Powell, *Essays on the Spirit of Inductive Philosophy, the Unity of Worlds, and the Philosophy of Creation* (1855).

generation would have accepted his portrayal of the discerning empiricist. There were practical men like the unfortunate gunner Giovanni Battista Renieri who aimed his artillery in accord with Galileo's theory of projectiles, only to complain that he kept missing his target. He had to be reminded by Galileo's pupil Torricelli that his master spoke the language of geometry and was not bound by any empirical result.[89] The methods of the real Galileo were certainly more subtle than Viviani implied. But his narrative provided the raw materials for many later accounts in which Galileo would be cast as

the heroic founder of modern science. One could set the heroic interpreter of nature against the obscurantism of the Church and so create a parable for one's own time. Wherever anti-Catholic and anti-clerical feelings ran high, as they so often did in Europe during the eighteenth and nineteenth centuries, Galileo would become an emblem for the causes of secularity and freedom of enquiry.

During the nineteenth century a hagiographic line became so entrenched, especially in Italy, that to question it was to suffer ignominy. A serious, six-volume, reappraisal was made by Raffaello Caverni in the 1890s. One of his concerns was that Galileo had scooped the credit for many innovations that should be properly ascribed to his predecessors and contemporaries. But nobody wished to know. Since the unification of Italy, Galileo had been such a national hero that dissenting scholarship was marginalised.[90] In the English-speaking world, the 1870s saw John Draper returning to the Galileo affair when blasting new claims for papal infallibility. 'What a spectacle!', Draper exclaimed. 'This venerable man, the most illustrious of his age, forced by the threat of death to deny facts which his judges as well as himself knew to be true! He was then committed to prison, treated with remorseless severity during the remaining ten years of his life.'[91] Here is a classic statement of the mythology with which we began. Galileo's judges condemned him knowing that he was right.[92]

In the twentieth century the fate of Galileo was to have a profound contemporary relevance for Bertolt Brecht struggling against the oppression of Hitler and the Nazis in the late 1930s. In his play, *The Life of Galileo*, a drama unfolds in which the characters are all too human: we recognise vanity, passion, cunning, loyalty, betrayal and humiliation. For this reason, the play has a certain timeless quality: it has been described as a human tragedy of universal significance.[93] But it is also a play deeply rooted in its time. The pressing moral issue was how the responsible intellectual should behave in the face of an oppressive and terrifying regime. Through the life of Galileo, Brecht could explore the issue of intellectual liberty in the face of an absolute power. The issue was not now science versus religion. Brecht was using the Catholic Church in Galileo's day as an example, a symbol of autocratic power. We should not forget that there were frightening parallels in Nazi Germany. A Nobel Prize winner, the physicist Philipp Lenard had sought to banish Einstein from the community of scientists and was now busy on a substantial work of 'German Physics' designed to show that physics was an Aryan subject to which Jews had made no contribution.[94] It would be difficult to find a more telling example of the ideological uses of history. In his

play Brecht tackled the question of how truth could be spread in the face of oppression. The answer had to be illegally, as Galileo had done when smuggling his last great work out of the house where it had been completed.

In writing his play Brecht was forced to think about the moral responsibility of scientists themselves. He disliked the view that they should accumulate knowledge in ivory towers, with never a thought for the welfare of humanity. Once again there were events in the late 1930s that gave this question a new urgency. Scientists themselves were speaking of a new age in which undreamed-of energy could be unleashed from the atom. But with war looming, Brecht immediately saw that the scientists' dreams could turn into nightmares. He would write the prophetic line that 'practically every new invention is greeted with a shout of triumph, which immediately turns into a cry of horror'.[95] On 6 August 1945 the bomb was dropped on Hiroshima.

We have been referring to the contemporary relevance of the Galileo affair in the sense that each generation has found its own meanings in those events of long ago. New perspectives can come into force with explosive suddenness. Brecht was working on an English version of his play when the bomb fell. 'Overnight', he wrote, 'the biography of the founder of modern physics had to be read differently. The infernal effect of the huge bomb projected the conflict between Galileo with the authorities of his day into a new, sharper light.'[96]

Philosophers as well as playwrights have seen contemporary relevance in Galileo's life. In 1975 Paul Feyerabend published a book with the provocative title *Against Method*. His opposition was directed against attempts to construct formal accounts of scientific methodology which had the effect of imposing a spurious uniformity on disparate scientific practices. Feyerabend's aim was to show that 'science is an essentially anarchistic enterprise'.[97] History was the perfect accomplice. With acknowledgement to Lenin, he set out his stall: history generally, and the history of revolutions in particular, is always richer in content, more varied, more many-sided, more lively and subtle than even the best historian and the best methodologist can imagine.[98] Streamlined histories of science that purported to show the success of a unique and privileged methodology were a form of 'brainwashing' that had to be resisted.[99] What the history of science really showed was that progress had been made by breaking every rule in the book.[100] The proliferation of theories was to be encouraged. In fact the only principle that does not inhibit progress is that *anything goes*.[101]

Galileo's attempt to prove that the *earth* goes was now enlisted in support of this more chaotic image of science. On Feyerabend's reading we must emphatically not begin from the premise that Galileo had the truth on his side. There is a sense in which the Copernican system could be said to have been refuted. Only with *ad hoc* assumptions, such as the expansion of the universe, could it be saved. Nor was it obvious that the images Galileo had seen through his telescope were to be trusted. In fact his own report of the lunar surface showed a crater so large that it ought to be visible to the naked eye. Since the circle did not square with what could be seen, Feyerabend spoke of another 'refuted view' – that is the view that telescopic phenomena are faithful images of the sky.[102] Speaking now as a historian, Feyerabend pressed his interpretation: 'while the pre-Copernican astronomy *was in trouble* ... the Copernican theory *was in even greater trouble*; but ... being in harmony *with still further inadequate theories* it gained strength, and was retained, the refutations being made ineffective by *ad hoc* hypotheses and clever techniques of persuasion'.[103] A long way indeed from the triumphalist rhetoric of scientific rationalism.

Feyerabend was speaking to a generation that, in his view, had come to revere too much the scientific experts with their stylised images of scientific rationality. Images of uniformity, whether of theory or practice, conveyed by the scientific community positively endangered 'the free development of the individual'.[104] Nor did he pull any punches. As the accepting and rejecting of ideologies should be left to the individual, it followed that 'the separation of state and *church* must be supplemented by the separation of state and *science*, that most recent, most aggressive, and most dogmatic religious institution'.[105] Tendentiously he wrote of science as a kind of superstition. And, horror of horrors to those on the inside, he even envisaged circumstances in which the State, political party *or the Church* might have to interfere in order to re-direct research priorities.[106] We seem to have come full circle. But times have changed again. In the 1990s we are more conscious of the need to restore public confidence in scientific expertise and to reverse that broader cultural trend towards the devaluation of scientific authority which has taken turns that even Feyerabend may not have envisaged in the 1970s.

Do we have a Galileo for today? Because fashions change within the practice of history, new images keep appearing. Galileo the courtier appeared in 1993. His advocate Mario Biagioli showed how at critical junctures in Galileo's career his fortunes were tied to his quest for patronage.[107] Thus his dedication of the moons of Jupiter

to the Medici family was a calculated gift, part of the etiquette that he hoped would win him the patronage of the new Grand Duke Cosimo II whom he had earlier taught. It worked wonderfully well and in 1610 he was able to leave Padua for Florence. Here he enjoyed not merely more leisure for his work, but enhanced social status as court philosopher. Biagioli notes the earnest diplomacy through which he secured for himself that title: not merely mathematician but philosopher to the Grand Duke of Tuscany. The distinction was emblematic of the status Galileo wished to confer on the Copernican system: no mere mathematical device but a physical system worthy the attention and defence of the philosopher.[108] Later in his career Galileo courted his friend Barberini when he became Urban VIII. This time the dedication of his book *The Assayer* to the new Pope was the self-commending gift. Papal patronage, after all, would be the most glittering prize. From this courtly perspective many features of Galileo's behaviour can be seen in a new light.

For example, it was part of one's duty as a court philosopher to respond to the provocation of others because the honour of one's patron was at stake. One had no choice but to retaliate and the dispute had the character of a duel. This helps us to understand the vituperative, insulting style that Galileo would adopt in such disputes. It was all part of what was expected in a good duel.[109] Galileo's aggressive style has often been seen as a character trait that helps to explain his downfall. As Arthur Koestler once put it, with every argument that he won he was apt to make a new enemy.[110] But, as Biagioli observes, 'once it is contextualised within these patronage dynamics Galileo's well known aggressive and sarcastic style ceases to be just a character trait'.[111] Biagioli's line, that science was an admirable subject for a duel, makes it appropriate to talk about the patron's aesthetics of good sport.[112] This may seem a long way from heavy issues concerning scientific truth; but, on Biagioli's reading, it is not because one of the rules of the game was that one should not bring the debate to a definitive conclusion. The sport lay in the sparring, the rhetorical display, not in what the sociologists of science call closure. This may be the reason, Biagioli suggests, why Galileo was so insistently told that he should present the Copernican system only as a hypothesis. When it suited his purpose, he would play by the rules, as in his controversy with Grassi. On the nature of comets he did not commit himself to any one theory.[113] But, as Biagioli points out, he did not play by the rules in his *Dialogue*. There he thwarted the 'refined eclecticism' that conventionally protected the patron from having to take a stand.[114]

What light does this shed on the trial itself? Biagioli suggests that the rise and fall of Galileo conforms to a well documented pattern in the courtly life of the period: the rise and fall of a favourite, whose fall, once triggered, becomes absolute, swift and inexorable.[115] A characteristic of many such falls was the pretext spelled out by the patron: he had been betrayed.[116] And because he had been betrayed by a close friend there was no alternative but to take decisive action. The way Urban VIII spoke of Galileo was in precisely these terms. As we have already seen, it was not difficult for him to do so. His own wishes concerning the *Dialogue* had certainly not been respected.

We may also ask what bearing this may have on traditional accounts of the 'conflict between religion and science'. Biagioli is perfectly explicit on this point. The conflict between a Christianised Aristotelian and a Copernican cosmology was certainly a trigger that precipitated this most famous of trials. But his thesis is that 'the events of 1633 were as much the result of a clash between the dynamics and tensions of baroque court society and culture as they were caused by a clash between Thomistic theology and modern cosmology'.[117]

Historical Plausibility

Clearly the contemporary relevance of the Galileo affair has not only changed with time and context but has depended very largely on the presuppositions of the historian. This, however, raises an obvious and disturbing problem. Can we all have the history we want? Are there no controls? Are all histories historical novels? Can an innovative interpretation ever be refuted?

The reaction to another recent account suggests that a degree of consensus can be achieved if a historical argument ceases to look plausible. An exciting new slant on the Galileo affair was published by Pietro Redondi in 1983. In his book *Galileo Heretic*, he suggested that the principal heresy of which Galileo was guilty was not his Copernicanism but rather his commitment to a dangerous theory of matter.[118] This set a cat among the pigeons. It was well known that, in his *Assayer* of 1623, Galileo had included a short passage in which he argued that tastes, smells, colours, and sensations such as tickling, were precisely that – subjective sensations produced in us by an ulterior world of colourless, odourless, particles. It was also well known that Galileo correlated the sensation of heat with the motion of corpuscles. Redondi's message was that this departure from an Aristotelian theory of matter was theologically dangerous because it

compromised an essential element in Catholic worship – the transubstantiation of bread and wine into the body and blood of Christ. The language of transubstantiation made sense in terms of a theory of matter that sharply distinguished between substance and form. There could be a miraculous change of substance without change in the external appearance of the bread or wine. On the corpuscular view, however, the external appearances depended on the ulterior structure and arrangement of particles. A miraculous change in the substance would have sensible consequences.[119]

The plot thickened when Redondi produced an anonymous document from the Vatican archives in which reservations about this aspect of Galileo's *Assayer* were expressed. Moreover, he argued that it was the work of none other than Galileo's Jesuit opponent Grassi, with whom he had quarrelled over comets. Into a brilliant account of the political complexities of the case, Redondi wove his startling thesis. The trial of 1633 was not about Copernicanism at all. It was a show-trial, a façade behind which Galileo's real crime could be concealed. Under political pressure the Pope had thrown Galileo to the wolves to appease his critics, and conveniently to protect himself. Urban VIII was willing to shield Galileo from the worse charge concerning the Eucharist because he simply could not afford that issue to be made public. The *Assayer* had after all been dedicated to him and it would look as if he had been soft on a central point of doctrine. Redondi certainly supplied a new Galileo and a quite different angle on the trial. A new Galileo because he was presented not primarily as an astronomer or student of mechanics but as prime mover in the revival of atomism. And a new angle on the trial because Urban's protective attitude towards Galileo was not required to undergo any profound change.

How plausible is this reconstruction? It is impossible to do it justice in a brief compass; but something like a consensus has emerged among Galileo scholars that it is not plausible enough.[120] After all, the Copernican theory had been a genuine issue in 1616, seven years before the *Assayer* appeared. It also continued to be so in the years before the trial. In April 1625, Galileo was warned by his friend Mario Guiducci that to keep the Copernican opinion alive was to risk persecution from those who could punish with impunity.[121] And after the trial, as late as 1638, when Galileo sought permission for medical treatment in Florence, it was only granted by the Pope on condition that the Copernican doctrine was not to be discussed.[122] In that same year Galileo's old friend Castelli was warned 'under pain of excommunication' that he must not discuss with Galileo the condemned opinion of the earth's motion. It is difficult to reconcile

this intensity of papal concern over a private meeting with the claim that the trial had not been about Copernicanism.[123] Nor was Galileo ever able to persuade Urban VIII that he had not meant to mock him through the scepticism of Simplicio – a scepticism directed against a Copernican explanation for the tides. On Redondi's reading Urban almost becomes the hero who saved Galileo from a worse fate.[124] Yet this is difficult to square with the Pope's evident fury preceding the trial[125] and what has been described as an 'unremitting vindictiveness in private transactions'.[126]

Criticisms of another kind have surfaced. Few if any experts on Galileo have been persuaded that the document ascribed by Redondi to Grassi was composed by him. With a touch of irony one critic has added that Redondi's thesis would actually be stronger if Grassi was not the author because there would then be at least more than one person who allegedly saw a problem with Galileo's account of matter and its sensible properties.[127] This may be unduly severe because we know that corpuscular theories of matter developed later by Descartes did run into the sort of trouble on which Redondi's case rests. Nevertheless, the idea that Galileo's fate was determined by speculations on the nature of matter that he did not develop, rather than by the arguments for heliocentricism which he did, has proved difficult to sustain.

In conclusion it is hard to resist an aphorism acribed to Samuel Butler: though God cannot alter the past, historians can; it is perhaps because they can be useful to him in this respect that he tolerates their existence. History *is* invention, often brilliant invention; but it would not be appropriate to apply Feyerabend's aphorism that *anything goes*. Underlying all the complexities of the Galileo affair were ineradicable issues concerning the methods of gaining knowledge – both of nature and of God. One of the many respects in which Galileo chanced his arm was his claim that *as much* could be known of God through the study of nature as through the Scriptures.[128] In that claim he was raising the profile of natural theology, seemingly at the expense of revelation. The subsequent connections of natural science with natural theology will be the subject of the next chapter.

NOTES

1 M. A. Finocchiaro, *The Galileo Affair: A Documentary History*, Berkeley, 1989, 5.
2 Richard Griffiths, 'Very very frightening', *The Daily Telegraph*, 5 November 1994, 6.

3 For an apposite stress on the invisibility of the earth's motions and the difficulties this created for him, see R. Feldhay, *Galileo and the Church: Political Inquisition or Critical Dialogue*, Cambridge, 1995, 267–8.

4 John Paul II, 'Deep harmony which unites the truths of science with the truths of faith', *L'Osservatore Romano*, weekly English edn., 26 November 1979, in *Galileo Galilei: Toward a Resolution of 350 Years of Debate – 1633–1983* (ed. P. Poupard), Pittsburgh, 1987, 195–200.

5 For an introduction to the issues here, see T. S. Kuhn, *The Copernican Revolution*, Cambridge, MA, 1957; A. O. Lovejoy, *The Great Chain of Being* (1936), reprint edn., New York, 1960, 99–143; J. H. Brooke, *Science and Religion: Some Historical Perspectives*, Cambridge, 1991, 82–116; J. Dobrzycki (ed.), *The Reception of Copernicus's Heliocentric Theory*, Dordrecht, 1972; P. Rossi, 'Nobility of man and plurality of worlds', in *Science, Medicine and Society in the Renaissance* (ed. A. G. Debus), 2 vols., New York, 1972, ii, 131–62; R. S. Westman, 'The Copernicans and the Churches', in *God and Nature: Historical Essays on the Encounter between Christianity and Science* (ed. D. C. Lindberg and R. L. Numbers), Berkeley, 1986, 76–113.

6 S. Drake (ed.), *Discoveries and Opinions of Galileo*, New York, 1957, 27–58.

7 B. Wrightsman, 'Andreas Osiander's contribution to the Copernican achievement', in *The Copernican Achievement* (ed. R. S. Westman), Berkeley, 1975, 213–43.

8 The evidence that Martin Luther cited this verse against a heliostatic system was critically assessed by W. Norlind, 'Copernicus and Luther', *Isis*, 44 (1953), 273–6. That Galileo felt obliged to provide an exegesis of this text suggests that it had acquired a special significance in the debate, along with Psalm 93:1. Drake, op. cit. (6), 212–16.

9 S. J. Dick, *Plurality of Worlds: The Extraterrestrial Life Debate from Democritus to Kant*, Cambridge, 1982, 61–105.

10 It was clearly recognised by Tommaso Campanella that a plurality of worlds could be set up as an inference from, and therefore an argument against, Galileo's position. J. D. Moss, *Novelties in the Heavens: Rhetoric and Science in the Copernican Controversy*, Chicago, 1993, 153–4.

11 Drake, op. cit. (6), 158.

12 J. Reston, *Galileo: A Life*, New York, 1994, 147.

13 *Ibid.*

14 *The Controversy on the Comets of 1618* (ed. S. Drake and C. D. O'Malley), Philadelphia, 1960, 301.

15 The temptation to do this is still very strong even among informed commentators. At the end of his recent biography, James Reston refers to an interview he had had with Cardinal Poupard. He complains that he heard yet again the standard Church line – that Galileo had been condemned because he insisted on treating his Copernician theory as truth rather than hypothesis when he had no proof. Reston's impatience finds expression in a single sentence: 'This position deflected attention from a simple fact: The Copernican theory *was* true, and the church had used extreme and rigorous methods to crush that truth and protect its falsehood.' Reston, op. cit. (12), 285. With this sharp polarity between truth

and falsehood Reston glides over the fact that, in theory construction, truth has to be negotiated. The status of scientific hypotheses and the nature of the 'truth' that mathematical astronomy could supply were two of the issues at stake in the affair.

16 A. Fantoli, *Galileo: For Copernicanism and For the Church*, Vatican, 1994, 198–209.

17 *Ibid.*, 239 and 299.

18 M. Biagioli, *Galileo Courtier: The Practice of Science in the Culture of Absolutism*, Chicago, 1993, 351.

19 *Ibid.*, 301–2.

20 Reston, op. cit. (12), 190.

21 Fantoli, op. cit. (16), 299–300.

22 The relevant closing pages are reproduced in Finocchiaro, op. cit. (1), 217–18.

23 See the letter from Francesco Niccolini to Lord Bali Cioli, 28 August 1632, in Finocchiaro, op. cit. (1), 229.

24 In this respect it should be noted that Simplicio did not have the last word in the *Dialogue*. Although it was he who introduced the argument for scepticism based on divine omnipotence, Galileo carefully allowed Salviati, the chief protagonist, to agree with it. In retrospect his literary device looks like a grievous miscalculation, but it must have seemed to him an attractive way of creating consensus on what Salviati calls a 'truly angelic doctrine'.

25 Galileo, 'Letter to the Grand Duchess Christina', in Drake, op. cit. (6), 173–216, especially 175; also accessible in Finocchiaro, op. cit. (1), 87–118.

26 Biagioli, op. cit. (18), 236–8.

27 On the important exchange between Galileo and Conti, see M. Sharratt, *Galileo: Decisive Innovator*, Oxford, 1994, 103. Conti even referred Galileo to a commentary on *Job* by Diego de Zuñiga, where the Copernican system had been incorporated. He also indicated that the principle of biblical accommodation would permit conciliation between the new astronomy and Scripture – the very principle that Galileo later adopted in his apologetics. It is true that Conti advised caution, but, as on so many occasions, Galileo was able to reassure himself that there were ways forward.

28 *Ibid.*, 103.

29 Feldhay, op. cit. (3), 34–44.

30 Drake and O'Malley, op. cit. (14), 17.

31 For commentary on Brahe's geoheliocentric system, see O. Gingerich and R. S. Westman, 'The Wittich connection: conflict and priority in late sixteenth-century cosmology', *Transactions of the American Philosophical Society*, 78, Part 7 (1988), 1–148; N. Jardine, *The Birth of History and Philosophy of Science: Kepler's A Defence of Tycho Against Ursus, With Essays on its Provenance and Significance*, Cambridge, 1984. For Scheiner's willingness to centre the orbits of Mercury and Venus on the sun, which has itself been called 'revolutionary', see Feldhay, op. cit. (3), 260–1. And for Tychonic cosmology at the Jesuit College in Rome: J. M. Lattis, *Between Copernicus and Galileo: Christopher Clavius and the Collapse of Ptolemaic Cosmology*, Chicago, 1994, 205–16.

32 Moss, op. cit. (10), 151–2.
33 *Ibid.*, 160–1.
34 Feldhay, op. cit. (3), 93–127, 171–98, 256–91.
35 *Ibid.*, 53–4.
36 Fantoli, op. cit. (16), 388.
37 *Ibid.*, 119.
38 Galileo, op. cit. (25), in Finocchiaro, op. cit. (1), 92.
39 Bellarmine to Foscarini, 12 April 1615, in Finocchiaro, op. cit. (1), 67–9, on 68.
40 Galileo, op. cit. (25), in Finocchiaro, op. cit. (1), 101–2.
41 Galileo's tactics were however transparent in that he was cleverly shifting the burden of proof: 'before condemning a physical proposition, one must show that it is not conclusively demonstrated'. *Ibid.*, 102. This was one of many facets of Galileo's behaviour that incited an unsympathetic response from Arthur Koestler in *The Sleepwalkers*, Harmondsworth, 1964, 439–45.
42 Galileo, op. cit. (25), in Finocchiaro, op. cit. (1), 92–3.
43 To our knowledge, one of the first to analyse the inconsistency was Ernan McMullin in an as yet unpublished paper. It is also exposed by Sharratt, op. cit. (27), 123.
44 O. Pedersen, 'Galileo and the Council of Trent', *Journal of the History of Astronomy*, 14 (1983), 1–29.
45 Galileo, op. cit. (25), in Finocchiaro, op. cit. (1), 96.
46 Bellarmine, op. cit. (39), 68. Bellarmine immediately clarified what he meant by this: 'it would be heretical to say that Abraham did not have two children and Jacob twelve, as well as to say that Christ was not born of a virgin, because both are said by the Holy Spirit through the mouth of the prophets and apostles'.
47 Fantoli, op. cit. (16), 178.
48 Sharratt, op. cit. (27), 131 and 212–22.
49 W. R. Shea, 'Galileo, Scheiner, and the interpretation of sunspots', *Isis*, 61 (1970), 498–519; Feldhay, op. cit. (3), 256–91.
50 There is a letter from the Vatican secretary to the Florentine Inquisitor, dated 24 May 1631, in which it is explicitly stated that 'Our Master thinks that the title and subject should not focus on the ebb and flow but absolutely on the mathematical examination of the Copernican position.' Finocchiaro, op. cit. (1), 212.
51 Finocchiaro, op. cit. (1), 9. See also *ibid.*, 20–24 for the new physics that was required in order that arguments for a moving earth could be sustained.
52 Thus a superficial reading of Galileo's abjuration, in which he confessed to having adduced 'very effective reasons' in favour of a condemned doctrine, might leave the erroneous impression that the prosecution had conceded the strength of his scientific defence. Finocchiaro, op. cit. (1), 292; Fantoli, op. cit. (16), 423–5.
53 Finocchiaro, op. cit. (1), 139.
54 R. J. Blackwell, *Galileo, Bellarmine and the Bible*, Notre Dame, 1991, 16.
55 *Ibid.*, 18.

56 *Ibid.*, 19.
57 J. Dillenberger, *Protestant Thought and Natural Science*, London, 1961, chs. 1–3.
58 F. Yates, *Giordano Bruno and the Hermetic Tradition*, Chicago, 1964, 348–59.
59 Galileo, op. cit. (25), in Finocchiaro, op. cit. (1), 114–18. Galileo argued that the miracle only required the sun to stop turning on its axis for a while and all the planetary motions would temporarily cease. The beauty was that this would not involve a violation of the entire cosmos, as would be the case if the sun had been stopped in its tracks on the old system.
60 When denouncing Galileo, Caccini drew attention to his friendship with Sarpi, 'famous for his impieties'. Finocchiaro, op. cit. (1), 139. On the Venetian revolt against Rome, see P. F. Grendler, *The Roman Inquisition and the Venetian Press, 1540–1605*, Princeton, 1977.
61 Brooke, op. cit. (5), 94–9.
62 Fantoli, op. cit. (16), 170–1.
63 *Ibid.*, 239 and 299.
64 G. de Santillana, *The Crime of Galileo*, Chicago, 1955; Reston, op. cit. (12), 239.
65 This political dimension has been given special prominence by P. Redondi, *Galileo Heretic*, Princeton, 1987.
66 Biagioli, op. cit. (18), 335.
67 *Ibid.*, 336.
68 In a letter to Elia Diodati, written by Galileo in January 1633, there is a forlorn prediction: 'From reliable sources I hear the Jesuit Fathers have managed to convince some very important persons that my book is execrable and more harmful to the Holy Church than the writings of Luther and Calvin. Thus I am sure it will be prohibited.' Finocchiaro, op. cit. (1), 225.
69 Fantoli, op. cit. (16), 459; Feldhay, op. cit. (3), 295–6.
70 S. Drake, *Galileo at Work: His Scientific Biography*, Chicago, 1978, 288. The extent to which the Jesuits could have helped Galileo, even if there had been a wish to do so, has been re-examined by Fantoli, op. cit. (16), 213–15, 243, 277, 428–30, 435 and 459–61. Fantoli stresses that within the Jesuit Roman College the mathematicians and astronomers were a small minority. For the philosophy teachers there was as yet no serious alternative to the comprehensive system of Aristotle. To compound the difficulty, the Father General of the Jesuit Order, Claudio Acquaviva, had been issuing instructions to maintain their unity through renewed allegiance to Aristotle. *Ibid.*, 126–7, 215.
71 R. S. Westman, 'The Melanchthon circle, Rheticus and the Wittenberg interpretation of the Copernican theory', *Isis*, 66 (1975), 165–93; *idem.*, 'The astronomer's role in the sixteenth century: a preliminary study', *History of Science*, 18 (1980), 105–74.
72 Moss, op. cit. (10), 156.
73 Sharratt, op. cit. (27), 41. The efforts of Clavius to raise the status of mathematics and astronomy and their linkage to questions of natural philosophy are most fully discussed in Lattis, op. cit. (31).

74 Feldhay, op. cit. (3), 44–69.
75 Sharratt, op. cit. (27), 145; Finocchiaro, op. cit. (1), 35.
76 Fantoli, op. cit. (16), 306.
77 For the honour and esteem ostensibly accorded to Galileo at the Papal Court as late as June 1630, see the letter from Francesco Niccolini, the Tuscan ambassador, cited by Fantoli, op. cit. (16), 316.
78 Finocchiaro, op. cit. (1), 239.
79 N. Jardine, 'A trial of Galileos', *Isis*, 85 (1994), 279–83.
80 The warmth of hospitality shown to Galileo by Ascanio Piccolomini, Archbishop of Siena, following the sentence of house-arrest, has been taken to epitomise the unease of the more open-minded. Reston, op. cit. (12), 268; Fantoli, op. cit. (16), 510.
81 Fantoli attaches particular weight to the perceived mendacity of Galileo in turning the more unyielding of his judges against him. *Ibid.*, 425 and 477.
82 *Ibid.*, 475.
83 Reston, op. cit. (12), 285. It would be extremely difficult to delete Urban's involvement. See, for example, Finocchiaro, op. cit. (1), 38.
84 Sharratt, op. cit. (27), 215–16.
85 M. Segre, *In the Wake of Galileo*, New Brunswick, 1991, 116–22; Biagioli, op. cit. (18), 87–8.
86 Segre, *ibid.*, 123.
87 *Ibid.*, 35.
88 Sharratt, op. cit. (27), 50.
89 Segre, op. cit. (86), 43–4.
90 *Ibid.*, 44–5.
91 J. W. Draper, *History of the Conflict between Religion and Science* (1875), 18th edn., London, 1883, 171–2.
92 A few pages later, Draper included a passage which, had he thought through its implications, might have checked his allegation. He noted that there had been arguments against the Copernican system, particularly that of Tycho Brahe concerning the absence of stellar parallax. In reply to Tycho it had been said that the stars must be so far from the earth that the predicted effect is imperceptible. Draper knew that 'this answer proved to be correct'. *Ibid.*, 176. It proved to be; but when? In 1633 this expansion of the universe could still look like an *ad hoc* hypothesis designed to save the Copernican theory. On Draper's own account, two hundred years were to elapse before the parallax of Alpha Centauri was observed. *Ibid.*, 176. But his sights had been set elsewhere.
93 Finocchiaro, op. cit. (1), 4.
94 F. Ewen, *Bertolt Brecht: His Life, His Art and His Times*, London, 1970, 333.
95 *Ibid.*, 339.
96 *Ibid.*, 342.
97 P. Feyerabend, *Against Method*, London, 1975, 17.
98 *Ibid.*
99 *Ibid.*, 19.
100 One such rule, called by Feyerabend the consistency condition, dictated that new hypotheses must be in accord with accepted theories. This he

considered an unreasonable prescription because it preserves the older, not necessarily the better, theory. *Ibid.*, 11. There was, he believed, a kind of chauvinism within scientific communities that militated against what was really beneficial: the proliferation of theories.

101 *Ibid.*, 10.
102 *Ibid.*, 130–5.
103 *Ibid.*, 143.
104 *Ibid.*, 11.
105 *Ibid.*, 15.
106 *Ibid.*, 52.
107 Biagioli, op. cit. (18).
108 *Ibid.*, 89, 106–10, 128–9.
109 *Ibid.*, 61.
110 Koestler, op. cit. (41), 458–9.
111 Biagioli, op. cit. (18), 66, 71, 277; Jardine, op. cit. (79), 281. This need not lead to a whitewash of Galileo. There was a determination in his manner that attracted adverse comment. At the moment of crisis in 1616 one observer noted the 'violence' with which he forced his views on others. Reston, op. cit. (12), 166.
112 Biagioli, op. cit. (18), 75.
113 *Ibid.*, 303–5.
114 *Ibid.*, 301–3, 310.
115 *Ibid.*, 333–52.
116 *Ibid.*, 333.
117 *Ibid.*, 10.
118 Redondi, op. cit. (65).
119 *Ibid.*, 203–26.
120 R. S. Westfall, '*Galileo Heretic*: Problems, as they appear to me, with Redondi's thesis', *History of Science*, 26 (1988), 399–415; Fantoli, op. cit. (16), 341–4; Sharratt, op. cit. (27), 149.
121 Reston, op. cit. (12), 201.
122 Sharratt, op. cit. (27), 186.
123 Westfall, op. cit. (121), 412.
124 *Ibid.*, 406.
125 Niccolini, op. cit. (23). For a colourful if somewhat overdramatised account of the Pope's wounded sensibilities, see Reston, op. cit. (12), 236–44.
126 Westfall, op. cit. (121), 408.
127 *Ibid.*, 411.
128 Galileo, op. cit. (25), in Finocchiaro, op. cit. (1), 93: 'God reveals Himself to us no less excellently in the effects of nature than in the sacred words of Scripture.'