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# The Church and the new philosophy

*Peter Dear*

The pre-eminent social institution in the Europe of the sixteenth and seventeenth centuries was the Christian Church. A full understanding of the social place and meanings of the natural philosophical innovations that occurred during the period therefore demands consideration of the Church's role: the ways in which it incorporated those innovations, resisted them, or, more generally, constituted the context in which they were evaluated and used.

In fact, the events of the Reformation and Counter-Reformation mean that simply speaking of 'the Church' is inadequate in characterizing the cultural realities of the period; rather, the context for the ecclesiastical shaping of natural knowledge is set by the continual interactions of 'the Churches', Catholic and Protestant. That broad confessional divide is itself complicated further by the differences between Protestant denominations as well as among Catholics, especially those of different national traditions; some of the fine-structure of the issues to be examined in this chapter turn on precisely such disagreements. Two main themes will be considered. One is doctrinal or ideological, concerning ideas about God and the created world together with the policing of those ideas by the ecclesiastical apparatus. The other is institutional, concerning the formal social settings in which knowledge about nature was produced and taught: universities, colleges and schools run or heavily influenced by religious orders or denominations.

## 1 Natural philosophy and theology in the early sixteenth century

Contrary to a longstanding myth owing much to anti-ecclesiastical

Enlightenment thinkers of the eighteenth century, the high Middle Ages did not witness the imposition of a monolithic world-view by the Catholic Church that stifled independent creative thought about nature. In the thirteenth century the adoption of the works of Aristotle by the newly founded universities had provoked a crisis in traditions of academic theology that required accommodations to be made between views of the physical world as the product of God's free creation and criteria of rational inference about nature found in Aristotelian philosophy. A variety of approaches resulted. The two greatest synthesisers in the scholastic tradition were the Dominican Thomas Aquinas and the Franciscan John Duns Scotus. Aquinas, the greatest of the Christianizers of Aristotle, held that philosophy, in the sense of the independent use of human reason, was a proper handmaiden to theology, in the sense of a science based on divine revelation. There could be no conflict between truths of philosophy and truths of theology; the two were complementary and harmonious. The truths of philosophy, furthermore, were those indicated by Aristotle, including ideas about the natural world. Scotus differed from Aquinas in certain aspects of his philosophy, being in particular less strictly Aristotelian and more sympathetic to the older Platonic currents in Christian theology stemming from St Augustine.

The adoption of their differing philosophical perspectives in the fourteenth century did not entail the exclusive sanctioning by the Church of one at the expense of the other; different religious orders and different individual thinkers selected for themselves what they found useful or convincing. The early fourteenth-century Franciscan philosopher and theologian William of Ockham was considerably more controversial, denying basic elements of Aristotelian thought in favour of a philosophy that stressed God's absolute freedom to make the world in any way He chose – in contrast to Aquinas's belief in the power of human reason to discover much of God's work unaided by divine Revelation. Despite the political and theological difficulties in which he became embroiled, however, Ockham's philosophical ideas (known as 'nominalism') became widely influential over the next two centuries, in Italy as well as in northern centres such as Paris. These facts indicate both the lack of enforced philosophical uniformity by the Church throughout the later Middle Ages and early Renaissance and the lack of a single set of all-encompassing doctrines to which all elements of the Church subscribed.

By the beginning of the sixteenth century, therefore, ecclesiastical control of the philosophical ideas promulgated in the universities was, as earlier, restricted in practice to securing the boundaries of admissible doctrine rather than determining its content. There were certain positions that it was not permissible for philosophers to uphold, because of direct conflict with central tenets of theology – such as the immortality of the soul or the creation of the world. However, both of these, and others, were denied in Aristotle's writings, which formed the basis for philosophical instruction. Scholastic philosophers had developed a number of ways to deal with the problem. Aquinas had concentrated on 'correcting' Aristotle without falsifying him, so as to maintain a basic conformity between Aristotelian philosophy and theology; the Church leadership was already tending to favour Aquinas's position, but this was not in any sense an absolute orthodoxy.[1]

None the less, practically all educated Europeans in 1500 subscribed to one basic cosmological picture. Derived from Aristotle's account of the universe, but sharing its broadest features in common with that of Plato, it placed a spherical earth at the centre of a finite universe bounded by the sphere sustaining the fixed stars. The sun, moon and planets revolved on additional nested spheres of their own serving to carry them around the stationary earth. On the most common (but by no means canonical) interpretation, the celestial spheres, made of immutable 'aether', rotated by virtue of disembodied intelligences, usually identified with angels, which moved them in the same way as the soul moves the body. Aquinas had adapted an argument of Aristotle's to demonstrate on that basis the existence of God. Aquinas held that the ceaseless and unchanging rotation of the spheres cannot be explained (as Aristotle could explain the self-moved progress of animals) by the striving of their associated intelligences for their intended destinations, because the motion is circular; it does not go anywhere. Furthermore, there is no activity of motion beyond the spheres to provide any external motive force. The cause of the constant, uniform rotation must therefore be the striving of the intelligences to imitate the ceaseless, unchanging perfection of some transcendent Prime Mover, identifiable with God.

Although its static, hierarchical and theologically-integrated character, mirroring the authority and social structure of the Church itself, guaranteed this picture its high degree of established acceptance, it did not constitute official Church dogma. Its undogmatic status is rendered especially evident by the case of Nicholas of Cusa in the fifteenth century. Nicholas argued for a non-Aristotelian cosmology, rooted in theological and metaphysical considerations concerning God's omnipotence, which involved an infinite universe and an infinite multiplicity of other worlds. These unorthodox ideas, appearing in 1440, did not, however, prevent Nicholas from being made a cardinal in 1446 and from holding a number of other important ecclesiastical positions. Clearly, philosophically heterodox views concerning the natural world were not in themselves seen as a serious threat to theological orthodoxy.[2]

Deviance in natural philosophy began to appear more dangerous with the advent of the Protestant Reformation. While not necessarily conducive to heresy and social disorder, departure from tradition in matters concerning any aspect of learned culture could plausibly be seen by Catholic authorities as potentially disruptive of established authority. Nicolaus Copernicus's remarks in the dedicatory letter prefixed to his *De revolutionibus orbium coelestium* ('On the Revolutions of the Celestial Orbs') in 1543 express sentiments appropriate to a period of acute doctrinal anxiety. Addressing Pope Paul III, Copernicus, a Church canon, acknowledged that his doctrine of the earth's daily motion on its axis and annual motion around the sun was liable to meet with stern opposition. Indeed, the dedication to the Pope himself rather than to a local patron may perhaps be seen as a pre-emptive strike. The theological dangers were, Copernicus thought, real; he warned of 'idle babblers' who, though ignorant of mathematics, might condemn his work on the basis of 'twisting' scriptural passages.

Two years later the Council of Trent was convened to address those scandals which had been partly instrumental in provoking the ecclesiastical rebellion of the Protestants, and to respond to the Protestant challenge itself. The crisis impelled the leaders of the Catholic Church to impose strict disciplinary controls on moral errancy within its ranks; at the same time, the newly-flexed hierarchical muscle was applied to doctrinal matters. Just as concubinage was now firmly ruled to be an unacceptable interpretation of celibacy, so theological theses and devotional practices were subjected, after lengthy debate, to many restrictions and clarifications. Above all, the Counter-Reformation for which Trent came to stand signalled the determination of the Catholic Church to control dissent. Henceforth, many things would matter that once had been tolerated or ignored.





## 2 Doctrinal and institutional developments of the second half of the sixteenth century

The Council of Trent met intermittently from 1545 to 1563. Among its decisions relating to ideas about the natural world and how to know it were the following. First, because the large number of Catholic miracles served in polemical attacks on miracle-bereft Protestants as evidence of divine approval (continuing to do so throughout the sixteenth and seventeenth centuries), Catholic stress on this argument rendered careful management of miracles of great importance. Accreditation of miracles was accordingly brought under formal ecclesiastical control, whereby a judicial procedure was established to review claimed instances of miraculous events. Since miracles were defined as events caused directly by God that suspended or violated natural processes, nature itself had on this view to be seen as governed by firm and unalterable regularities: miracles were only possible if there were natural regularities to violate. Catholic orthodoxy therefore encouraged a knowledge of nature that stressed order and intelligibility rather than disorder and caprice. At the same time, divination and magic, including astrology, were firmly repudiated.[3]

Secondly, the Council approved rules for the proper interpretation of Scripture. These were designed to combat the Protestant view that the individual believer, properly illuminated by the Holy Spirit, could determine the true meaning of the text unaided by ecclesiastically-sanctioned authoritative readings. The Council made the authority of the established interpretation of any particular biblical passage paramount, with especial weight given to the consensus of the early Church Fathers.[4]

These decisions were to have considerable consequences for dealing with apparent conflicts between biblical statements about the natural world and assertions of natural science, conflicts of exactly the sort foreseen by Copernicus.

The effort to control theological doctrine as a means of demarcating admissible Catholic teaching from heresy also involved the elevation in 1567 of St Thomas Aquinas to the status of an official Doctor of the Church.[5] His Aristotelian natural philosophical worldview together with its epistemological foundations therefore became implicated in the new Catholic regime. Although variance from Thomistic-Aristotelian teachings in natural philosophy did not usually itself constitute religious deviation, adherence to those teachings became for the most important of the teaching orders, the Dominicans and the Jesuits, a matter of prudence and propriety. One central theological doctrine, however, raised the possibility of direct conflict with natural philosophy. In determining the proper Catholic response to various Protestant interpretations of the Eucharist, the Council of Trent had elevated the characterization first developed by Aquinas into a matter of orthodoxy: the doctrine of transubstantiation was interpreted in Aristotelian philosophical terms that established precisely how it should be regarded as miraculous. The bread and wine, contrary to a number of alternative Protestant views, truly became the body and blood of Christ.[6] The miracle consisted in the retention of the 'accidents', the sensible properties, of the bread and wine in the absence of their actual 'substance', the stuff itself, to act as the possessor of those properties (the accidents of the bread and wine were not allowed to subsist in the body and blood of Christ itself). This central element of Catholic doctrine thus became closely associated with Aristotelian teaching on the metaphysics of substance, which necessarily involved questions of the nature of matter.

Finally, the *Index of Prohibited Books* was established in this period as a policing mechanism to control publication, possession and reading of heretical literature – the chief medium by which the rulings of Trent might be undermined.[7]

Theological and ecclesiastical features of the newly emerging Protestant world also had implications for the study of nature, although the apparatus of enforcement was less effective than that of the Catholic Church. Most famously, in 1539 Martin Luther had casually condemned the opinions of Copernicus as those of a fool who 'wants to turn the whole art of astronomy upside down'.[8] However, this was an isolated instance of such an attitude, although the anonymous preface to *De Revolutionibus* inserted by the Lutheran theologian Andreas Osiander (without Copernicus's knowledge) stressed that the motion of the earth was just a hypothesis designed to yield accurate predictions; it should not be taken as physically true. Osiander's apparent misgivings, similar to Copernicus's – though handled in a less bold manner – were borne out in the early reaction to Copernican astronomy by the intellectual pilot of Lutheranism, a man responsible for the establishment or reform of a number of Lutheran universities in Germany, Philipp Melanchthon. Melanchthon at first dismissed it as gratuitous novelty, but soon softened his attitude in the face of fruitful application of Copernicus's mathematical





– although not cosmological – ideas by astronomers at his own University of Wittenberg. Thus, while rejecting the motion of the earth on scriptural grounds, he accepted Copernicus's book as a useful tool in a true reform of astronomy.

Natural philosophy at the Lutheran universities, as with other fields, followed Melanchthon's prescriptions and suggestions closely. His first impulse when embarking on this task of educational reform was to replace Aristotelian natural philosophy in the curriculum entirely, because of its close association with Catholic scholastic wrangling over its theological implications. He therefore tried using Pliny's *Natural History* as the central text for an entirely new approach. Before mid-century, however, this had proved impractical, being both too restrictive and too disruptive of established patterns of university pedagogy. In the event, Melanchthon himself wrote school commentaries on a number of Aristotle's natural philosophical works.[9]

The direct relationship between the Churches and the study of nature in the second half of the sixteenth century, therefore, was one of potential rather than actual ecclesiastical shaping of natural philosophical orthodoxy. When, in 1553, Jean Calvin ordered the execution by burning of Michael Servetus, nowadays best known for his novel ideas on the movement of the blood through the lungs, he did so because of Servetus's heretical views on the Trinity, not for physiological unorthodoxy. Much the same can be said of Giordano Bruno, burnt at the stake in Rome in 1600 not for his advocacy of Copernicus's moving earth, as used often to be claimed, but for heresy it would have been difficult for the Roman authorities to overlook.

## 3 A case-study of intellectual and political tensions: the Galileo affair

The potential shaping of natural philosophy by the Churches became actual conflict in the celebrated case of Galileo's condemnation. The central issue concerned the rules of biblical exegesis. Most theological dogma, such as the divinity of Christ or the immortality of the soul, could be acknowledged and ignored by students of the natural world: little of what they had to say could be deemed as challenging that dogma, and throughout this period, with one or two notable exceptions, little was. The arena of relevant intersection became much enlarged, however, if the entire text of the Bible was made the touchstone for doctrine even on non-theological matters.

The Council of Trent explicitly invoked the interpretations of the Church Fathers as supreme authorities in biblical exegesis so as to avoid the freedom of individual interpretation claimed by the Protestants. Unlike Catholic orthodoxy, which placed Church tradition at least on a par with holy writ as a source of religious authority, Protestant theology of whatever stripe treated the Bible, together with the divinely illuminated believer's act of reading it, as the only true basis of Christianity. In practice, however, no one maintained that every word should be read literally, since that would create absurdities such as the attribution to God of human characteristics – unstable emotions like anger, or even the possession of hands or a face – or the untenability of a literal reading of the Song of Solomon. Guidance on appropriate exegetical techniques had therefore always formed an important part of Christian tradition. For Protestants, who insisted on the corruption of the Church since the time of the Church Fathers in the early centuries of Christianity and whose reforms aimed at restoration, St Augustine was an especially favoured authority in this as in all matters.

Augustine's views, expressed in his commentaries on Genesis, required as the first, preferred option in interpreting a biblical passage a literal reading. But other options were also available. In those cases where a literal reading conflicted with the informed judgement of an educated man, as with the attribution of certain inappropriate human characteristics to God or, indeed, the description of the heavens as a tent sheltering the earth (in clear conflict with the demonstrations of Greek astronomical science), it became permissible to take account of the historically-situated expectations of the audience. God, speaking through His divinely inspired servants and prophets, was thus portrayed as a classical rhetorician. The common people to whom, for example, Moses spoke would only have been distracted from the central message if ordinary language and ordinary perceptions of things indifferent to the theological or religious message at hand were replaced by strictly accurate speech. Describing God as angry served its purpose even though it was only a metaphorical characterization; describing the heavens as a tent fitted the simple ideas of the Israelites where speaking of a geocentric spherical universe would have confused them.

This line of argument, subsequently used by Aquinas and well-established in the sixteenth century, offered a powerful tactic to any natural philosopher who might be challenged on grounds of conflict with some statement in the Bible. The (admittedly somewhat heterodox) Lutheran Johannes Kepler invoked it in the introduction to his *Astronomia nova* of 1609, the book in which he set out his first two laws of planetary motion. He maintained that 'the Sacred Scriptures, speaking to men of vulgar matters (in which they were not intended to instruct men) after the manner of men, so that they might be understood by men, do use such expressions as are granted by all, thereby to insinuate other things more mysterious and divine'.[10] Kepler's arguments met with little ecclesiastical opposition, and his astronomical work never led him into difficulties; Protestant churches in general ignored the matter, along with other natural–philosophical novelties. But the clarity, forcefulness, and authority of Augustine's statements also appealed to the Catholic Galileo. His deployment of them under the auspices of a Church that guarded jealously its privileges of authorising theological discussion, and that had the power, especially in most of Italy,[11] to enforce its will, led to a confrontation that Kepler never had to face. The Catholic Church had a greater ability to impose its stamp on its territories than the majority of Protestant denominations could achieve; the differences were not essentially theological.

The story of Galileo's condemnation in 1633 and his earlier encounters with Church authority has been told often, and there are now a number of reliable treatments to replace the sectarian polemics of much of the last century. Galileo had a talent for making enemies as well as friends, and in 1614 a Dominican priest called Tommaso Caccini issued an unauthorized denunciation from the pulpit of his well-known Copernican views. Caccini used the weapon of scriptural quotation, deploying such standard passages as Joshua's command to the sun to stand still (Joshua 10: 12-13), which apparently implied that the sun genuinely has a proper motion through the sky rather than merely reflecting the diurnal rotation of the earth. The issue of the role of Scripture in judging Copernicanism had cropped up in dinner conversation during the previous year among a group that included the Grand Duchess Christina, the mother of Duke Cosimo II de' Medici of Florence (Galileo's patron), and Benedetto Castelli, a protégé of Galileo. Castelli reported the exchange to Galileo, who determined to compose a response to the scriptural challenge. The result, a much-expanded version of his response to Castelli, was Galileo's famous *Letter to the Grand Duchess Christina*, finished in 1615 (not printed, although widely circulated in manuscript, until 1636).

The Letter addresses both the general issue and, more specifically, points made in 1615 by Cardinal Robert Bellarmine, in a criticism of another champion of Copernicanism, the Carmelite priest Paolo Antonio Foscarini. Bellarmine's importance in this matter stemmed from his enormous power in the Catholic Church: he was papal theologian, Father Commissary to the Holy Office (the Inquisition), and wielded immense influence in Vatican affairs. Consequently, Galileo was obliged to confront his views if Copernicanism were to be inserted comfortably into the overall cultural complex of the Catholic world. Bellarmine adhered to a fairly hard line on the issue of scriptural interpretation: of course a literal reading should always be the first resort, to be modified only when there were adequate reasons to do so; but those reasons had to be unusually good, such that even in questions of natural philosophy the words of Scripture needed solid demonstrative arguments, not just likely ones, to justify metaphorical or figurative readings. Thus he told Foscarini that Copernicanism might indeed require reinterpretation of some apparently conflicting biblical passages, but only if it were to be proved with demonstrative certainty – something he doubted could ever be done.

This left Galileo in a bind. With characteristic self-confidence, he accepted Bellarmine's criteria (which also squared with certain Augustinian passages), and then insinuated that Copernicanism could indeed be demonstrated. He made a visit to Rome from Florence in late 1615 and early 1616 especially to forestall any official Church action against Copernicanism in the face of Bellarmine's opposition and the agitation caused by Caccini and others. However, despite his touting of a purported proof of the motion of the earth from the tides, Copernicus's opinion was declared 'formally heretical', Foscarini's tract condemned, and Copernicus's book placed on the Index 'pending correction'. The corrections, finally issued in 1620, concerned those statements in *De revolutionibus* clearly showing that Copernicus regarded the doctrine of the motion of the earth as a fact rather than as a hypothesis convenient for making calculations.[12] Galileo's name appeared nowhere in the 1616 condemnation, although he was certainly at the centre of the business and had private meetings with Bellarmine. He asked for, and received, a certificate from Bellarmine confirming that Galileo had not himself been condemned for supporting Copernicanism. However, there also exists an unsigned and unwitnessed document in the relevant Vatican file to the effect that Galileo had been enjoined by Bellarmine (and had, naturally, acquiesced) never again to maintain or even discuss Copernicanism. This document was later brought forth as the central legal plank on which Galileo's condemnation was based; it has variously been accounted a forgery, or, most recently and persuasively (by Richard S. Westfall), a quiet enjoinder typical of Bellarmine's political style.





Galileo met his fate through over-confidence. Chastened by the 1616 ruling, he kept quiet about Copernicanism for several years. In 1623, however, a fellow-Florentine, Maffeo Barberini, was elected Pope, and he granted Galileo a number of private audiences during the following year which left Galileo believing that he had been permitted once again to discuss the question. He gained this impression from Urban VIII's observation that the motion of the earth, although unlikely to be demonstrable, had never been condemned outright as heretical ('formally heretical' clearly meant something importantly different for Urban). The final result of Galileo's new confidence, the vernacular *Dialogue Concerning the Two Chief World Systems*, appeared in Florence in 1632. Perhaps partly due to suggestions that he was being personally ridiculed, Urban took strongly against Galileo: in a section at the close of the book an argument that Urban had upheld against Galileo is presented by the dialogue's frequently ridiculed straw-man character. It is probable also that Urban felt pressured into responding sternly to Galileo's presumption because of his political position: powerful Spanish interests in Rome disliked Urban's friendliness towards the French and criticized his perceived liberal attitudes; the Galileo affair obliged him to demonstrate his willingness to impose the Church's authority. Thus, in 1633, on the legal basis of the aforementioned document by the long-deceased Bellarmine, Galileo was forced to renounce his views and condemned to house arrest for life. An affair inflamed by issues of proper biblical exegesis ended with an exercise of power by those who guarded the privilege of discussing them.

The fallout from the 'Galileo affair' is difficult to judge. Perhaps the greater power of the Vatican's arm in Italy restrained Copernican speculation there; certainly, it was not a prominent item on the philosophical agenda subsequently in the century (although see below on the Jesuits). In France, however – perhaps the most philosophically vital territory in the Catholic world outside Italy – response to the Church's action was fairly restrained. The independent Gallican traditions of the French Church, always suspicious of Roman interference, seem to have left the matter of official suppression of

Copernicanism a dead letter; the condemnation was never promulgated there. After the initial consternation of French natural philosophers such as Marin Mersenne and Pierre Gassendi – both priests – the ruling was quietly overlooked; sympathetic discussion of the motion of the earth, albeit with due caution, took place throughout the 1630s and 40s without interference. However, Mersenne's frequent correspondent René Descartes, by that time living in the Netherlands, took sufficient alarm at the news of Galileo's fate that he suppressed a treatise detailing the structure of the universe because it required the motion of the earth. Only eleven years later, in 1644, did he publish a greatly elaborated version of that world-system wherein he took care to stress his principle of the relativity of motion so as to avoid implying the reality of absolute terrestrial motion. For Protestants, Galileo's condemnation had a different consequence: it served as a useful piece of anti-Papist propaganda.[13]

## 4 New natural philosophies and new theories of matter: the problem of transubstantiation

We saw in Section 2 how the Tridentine reforms of the Catholic Church tightened up doctrines on transubstantiation in the miracle of the Eucharist. In particular, the philosophical basis of the doctrine developed along Aristotelian lines by Thomas Aquinas, although not made part of dogma, took on an air of orthodoxy that made speculation on alternative views of matter a delicate undertaking. From the beginning of the seventeenth century onwards, classical Greek atomism began to attract attention from repudiators of Aristotle's natural philosophy. Atomism involved the denial of real qualities in bodies, viewing them as simply artefacts of the sensory process. For Aristotle, properties such as redness or hotness were objective qualities of bodies, residing in them whether or not they were observed. Atomism, as developed by Leucippus, Democritus and, especially, Epicurus, held on the contrary that the appearance of such qualities arose from the effect on the senses of atomic particles of different shapes, sizes and motions – these being the only true properties of material things. Thus, for example, bodies were not in themselves hot; the sensation of heat arose from the agitation against the flesh of appropriately shaped sharp particles, so that heat reduced to something else. However, denial that most human categories of perception corresponded to distinct realities in the world in effect





challenged the Thomistic account of the Eucharist.

Aquinas had maintained that the appearances, or 'accidents', of the bread and wine remained even though the 'substances', the underlying things themselves, transformed into the body and blood of Christ. This conceptualization may be compared to the transformation of a Georgian private house into a medical clinic: the appearance of the building may remain basically unchanged, even inside, but its nature has changed from one kind of thing, a house, into another, a clinic. In the miracle of the Eucharist, however, the relevant accidents were almost all qualities of the kind that atomists asserted to be illusory – taste, colour and so forth. On this view, the Aristotelian claim of a real distinction between a thing's accidents, or properties, that our senses detect, and its substance, in which the accidents subsist and which constitutes the thing in itself, disappears. Accidents become merely subjective correlates of objectively identifiable atomic characteristics; if their atomistic substrate – in effect, the 'substance' – changes, then so do they. Thus the philosophical assumptions on which Aquinas's account of transubstantiation was based would no longer hold. Although the Thomistic interpretation was not an article of faith, so that in principle an alternative could always be developed, any implicit challenge to it without the presentation of a theologically acceptable substitute risked the appearance of heresy, since it could be held to deny the reality of transubstantiation altogether.

The seriousness of the issue is revealed in criticisms levelled, once again, at Galileo. In the course of a dispute spanning several years, a leading Jesuit mathematician at the Collegio Romano, the flagship of the leading Catholic teaching order, drew attention to the problems for understanding orthodox doctrine on the Eucharist that were implied by Galileo's remarks, in his book *Il Saggiatore* ('The Assayer'), published in Florence in 1623, about the physical basis of qualities such as taste, odour and colour. Orazio Grassi, in a treatise of 1626, draws attention to Galileo's atomistic account of qualities as sensations within us caused by the motion and shape of particles. He then expresses misgivings derived from 'what we have regarded as incontestable on the basis of the precepts of the Fathers, the Councils, and the entire Church' concerning the miraculous maintenance of the qualities of the bread and wine in the absence of their substance. Since Galileo denied that these kinds of properties were objectively real, being nothing but names attached to subjective impressions, Grassi asks 'would a perpetual miracle then be necessary to preserve some simple names?'[14]

An anonymously-authored document recently discovered among papers at the Vatican relating to the 'Galileo affair' and presumably also dating from the 1620s contains similar observations about Galileo's atomistic speculations. Although it seems unlikely that this problem was the main cause of Galileo's troubles, its potential for undermining precisely the sorts of ideas that were becoming characteristic of the new views in natural philosophy in the early seventeenth century is clear. The question of the Eucharist became a significant weapon in the public arena of debate on the nature of matter and qualities soon afterwards, with reaction to Descartes's *Meditations* of 1641.

Antoine Arnauld, who in 1641 became a Doctor of Theology at the Sorbonne and subsequently a leader of the heterodox Jansenist movement in French Catholicism, wrote the fourth of a series of six 'Objections' appended, together with the author's replies, to the first edition of Descartes's work. Arnauld concludes a number of queries about Descartes's metaphysical arguments and the religious delicacy of the issues they confront with remarks very similar to those raised by Grassi against Galileo, worrying that 'according to the author's doctrines it seems that the Church's teaching concerning the sacred mysteries of the Eucharist cannot remain completely intact'. The problem is that Descartes 'thinks there are no sensible qualities, but merely various motions in the bodies that surround us which enable us to perceive the various impressions which we subsequently call "colour", "taste" and "smell".' Sensible qualities are unintelligible without their underlying substance; after transubstantiation there would be no qualities of bread and wine for God to sustain miraculously.[15]

Descartes's attempts at solution of the difficulty both in his 'Reply' to Arnauld's objections and in letters of 1645 and 1646 to a Jesuit correspondent, Denis Mesland, centred on two principal ideas. One involved stressing that, on his view of the origins of sense-perceptions, only the surfaces of the particles of bodies create sensory impressions. Surfaces, or superficies, are really only interfaces, not substances (in Descartes's terminology, they are 'modes'). Hence replacement of one substance by another, as in transubstantiation, could leave the appearances unchanged as long as the superficies of the particles were unaltered. This still left the problem of what it would mean for the substance to change if the figures and motions of the





particles remained the same, in so far as on Descartes's view of matter only those latter properties served to give a substance its nature and characteristics – matter itself was homogeneous and identical with spatial extension. However, Descartes came up with an alternative account of transubstantiation whereby Christ's soul joined with the bread in just the same way as human souls are usually joined with human bodies. The standard scholastic view of human beings was that they consisted of matter informed by soul to yield substance: the soul is what makes humans human. On this point, if on few others, Descartes agreed with the scholastics. He exploited the position by arguing in effect that if Christ's soul informed the bread, then that bread became, by definition, Christ's body. Descartes also suggested, most comprehensively of all, that both of these views of transubstantiation could be combined, so that Christ's soul combines with bread that has itself retained only its immaterial, modal superficies after a physical substantial change.

Descartes did not himself suffer for his questionable reinterpretations, even though they came dangerously close to Protestant views of the Eucharist. His correspondent Mesland was not so lucky: his superiors rewarded his sympathetic contact with Descartes by sending him in 1646 to serve in the Jesuit mission in Canada, where he remained until his death in 1672. In fact, dispute about Cartesian transubstantiation did not become serious until after Descartes's death in 1650, when Cartesianism took strong hold in France as a fashionable new philosophy. Followers of Descartes found that the Eucharistic issue was their most vulnerable point, since it involved the most fundamental aspects of Cartesian physics and metaphysics.

## 5 The Catholic Church and Jesuit science

The rapid rise of the Jesuit order to pre-eminence in Catholic education from its foundation in 1543 to the end of the sixteenth century is witnessed by both the founding of dozens of Jesuit colleges all over Catholic Europe (the number continuing to grow throughout the seventeenth century) and the reputation for excellence the Jesuits had acquired as educators even, grudgingly, among Protestants.[16]

The full curriculum offered by the Jesuits (although not necessarily covered in its entirety at all colleges) called for nine years of intensive, disciplined study by the mostly teenage boys who formed their clientele. The first six years, the 'course of letters', provided training in Greek and Latin grammar and rhetoric; the final three years, the 'course of philosophy', logic, ethics, mathematics, Aristotelian-style physics, and metaphysics.[17] The priestly teachers of these subjects were themselves typically of high scholarly attainment, and many of them, especially professors of mathematics, played a central part in the innovations of the Scientific Revolution.

The label 'mathematics' covered more than just the so-called 'pure' branches of arithmetic and geometry. It also included mathematical sciences of nature, pre-eminently astronomy (in its instrumental guise as a calculatory and computational science associated with, but not restricted to, practical matters concerning calendars and navigation), and optics. The establishment of mathematics so construed as an important part of Jesuit pedagogy owed much to the efforts of Christopher Clavius, until his death in 1612 professor of mathematics at the Collegio Romano (the same chair later occupied by Grassi). Clavius was the respected chief architect of the Gregorian calendar, which replaced the ancient Roman Julian calendar and put the Catholic world back in tune with the sun in 1582 (and left Protestant countries to catch up; Britain, for example, resisted until the eighteenth century). Clavius pushed hard for mathematics in the 1580s, during debates over a standardized curriculum for the colleges, chiefly on the grounds of its utility, both practical and interpretative (for understanding better the mathematical references in classical authors).

Consequently, from the early seventeenth century onwards there emerged Jesuit professors, themselves products of this educational system, highly adept in astronomy and optics and with corresponding attitudes towards the value of mathematical and instrumental approaches to nature. The official Thomistic Aristotelianism of the order tended to be interpreted quite flexibly: innovation appeared in all areas, including the work of the metaphysician Francisco Suàrez at the turn of the century and the slightly earlier theological ideas of Luis de Molina on free will and predestination. Not surprisingly, therefore, Jesuit astronomers were prepared to compromise in the face of Galileo's telescopic discoveries published from 1610 to 1613, which were presented as destructive of the incorruptible Aristotelian heavens and supportive of Copernicus. When Galileo came to Rome in 1611 to demonstrate his new discoveries of the satellites of Jupiter and the mountainous appearance of the moon, the astronomers of the Collegio Romano fully endorsed his claims. It was clear to them that the





existing orthodoxy was liable to change, and after the 1616 condemnation of heliocentrism the choice of Jesuit astronomers tended to be for some version of a Tychonic rather than Copernican system, wherein the earth would remain central and motionless but the planets would orbit the moving sun. Lectures in the 1570s by Robert Bellarmine, himself a Jesuit, had already allowed that the heavens were corruptible (an opinion he later retracted); his discussion of the heavens as composed primarily of elemental fire rather than aether is matched in a major work of 1630, *Rosa ursina*, by the leading Jesuit astronomer Christophorus Scheiner, where sunspots are the chief object of discussion.[18] Jesuit mathematical scientists generally welcomed innovations such as Galileo provided, although within certain prudential constraints: works of 1615 and 1620 by Clavius's former pupil Josephus Blancanus (Biancani) were censured by his superiors because of their open sympathy for Galileo's ideas.[19]

The new mathematical model soon found its way into Jesuit natural philosophy proper. Galileo's mathematical studies of motion, for example, appealing as they did to the model of Archimedean statics, were examined by a number of Jesuit natural philosophers. These included Roderigo de Arriaga at the college in Prague and Honoré Fabri in Lyons as well as the astronomer Giambattista Riccioli.[20] Much Jesuit work in natural philosophy from the 1620s onwards, including studies of the phenomena of magnetism and electricity by Niccolò Cabeo (who also investigated free fall), Athanasius Kircher and others shows the influence of experimentalism and the use of mathematically-structured arguments (expressed as 'theorems', 'propositions' and so forth) found in the classical mathematical sciences, especially optics. By mid-century, Kircher and his pupil Gaspar Schott were producing works that also investigated themes of natural magic, especially mechanical and hydraulic phenomena, very close to the interests characterizing the new mechanically-oriented natural philosophy of such men as Galileo, Descartes, Mersenne, Hobbes and Pascal.[21]

It should not be surprising, therefore, that both Descartes and Mersenne had been educated by the Jesuits (at the Collège de La Flèche), or that Galileo had from early on in his career close relations with Jesuits of the Collegio Romano, especially Clavius. The Jesuits, the intellectual vanguard of the Catholic Church, participated fully in the new philosophical developments of the seventeenth century even while having more sensitive regard to such issues as matter theory and

Copernicanism, and to the importance (pedagogical as well as doctrinal) of at least appearing conservative in their attitude towards Aristotelianism. It may even be that the stress on miracles as witnesses of the truth of Catholicism against the Protestants encouraged, as the backdrop against which genuine miracles could occur, a view of nature as a system of knowable regularities – the proper subject of scientific investigation. Priestly participation in philosophical novelty was, in fact, widespread even among non-Jesuits – Fathers Gassendi and Mersenne were among the first to test Galileo's claims about the behaviour of falling bodies.

## 6 Science and the churches: conflict, mutual accommodation or disinterest?

Tommaso Campanella, a renegade Dominican of the early seventeenth century, recommended natural philosophy as a Catholic tool by which to reconvert the Protestants through distraction and subversion.[22] Although Campanella got himself into considerable trouble for doctrinal deviance (on other grounds), the institutional role of the Catholic Church in the natural philosophical developments of the period up to 1650, and even beyond, was certainly in keeping with his recommendations: it fostered educational norms that embodied a view of the importance of the scientific study of nature, and allowed clerics to pursue that study both as teachers and independent investigators. As long as the new 'mechanical philosophy' associated especially with the work of Descartes remained no more than a contentious speculation, the vanguard of natural philosophical innovation could be maintained even while remaining within the boundaries of post-Tridentine Catholic orthodoxy. By the second half of the seventeenth century, however, a new European scientific community was coalescing around much stronger commitments to a world-view clearly transgressing the limits of scholastic Aristotelianism. The resultant officially-sanctioned reactions against it in Catholic countries thus pushed the Scientific Revolution beyond ecclesiastical succour.

There is no similar picture for the Protestant churches. Protestant church authorities seem to have lacked a certain sureness of touch, or effectiveness, compared to their Catholic counterparts in France, Italy or Spain. The frequent uncertainty attending the design of official university curricula after the break from Rome partly resulted from a suspicion of Aristotelian philosophy because of its association





with traditional Catholic theology – as is indicated by Melanchthon's flirtation with Pliny. If any generalization were to be made, perhaps, it might take the negative form of a stress on the weaker shaping of science, and hence a greater latitude for change, in Protestant territories: the introduction of Cartesianism into the universities of the Calvinist Netherlands in the 1640s or into the Academy of Geneva somewhat later, for example, contrasts with the resistance to it in Catholic France. It has also been claimed that the weakening of controls and censorship associated with the activities of Puritan reformers of the Church during the English Civil War and Interregnum of the 1640s and 50s was a factor in the success of English natural philosophy.[23]

Had it not been for the schism of the Reformation and the resultant need for the Catholic Church to define orthodoxy, and hence heresy, more strictly, the study of the natural world might have proceeded more freely than it actually did – at the least, there would have been no 'Galileo affair'. The newly-tightened authoritarian line on biblical exegesis and the greatly heightened sensitivity to potential challenges to the doctrine of transubstantiation formed significant dimensions of the Catholic parameters of legitimate natural science. But on the Protestant as well as Catholic side, knowledge of nature during this period was created in societies powerfully structured by ecclesiastical forces: the Church was a part of the life and thought of everyone.

## Notes

1 However, the Fifth Lateran Council in 1513 ruled that the doctrine of the soul's immortality could be positively proved philosophically, thereby putting philosophers on notice: Charles H. Lohr, 'Metaphysics', in *The Cambridge History of Renaissance Philosophy*, edited by Charles B. Schmitt and Quentin Skinner, Cambridge, 1988, pp. 537-638, p. 584.

2 *Ibid.*, pp. 548-56.

3 *Canons and Decrees of the Council of Trent: Original Text with English Translation*, edited by H. J. Schroeder, St. Louis and London, 1941, pp. 217, 276.

4 Robert S. Westman, 'The Copernicans and the churches', in *God and Nature: Historical Essays on the Encounter Between Christianity and Science*, edited by David C. Lindberg and Ronald L. Numbers, Berkeley, Los Angeles, London, 1986, pp. 75-113, on p. 89; *Canons, cit.* (n. 3), pp. 18-20.

5 William R. Shea, 'Galileo and the church', in *God and Nature, cit.* (n. 4), pp. 114-135, p. 115.

6 For Trent see *Canons, cit.* (n. 3), pp. 73-80.
7 Preliminary version 1559; so-called Tridentine Index 1564: Paul F. Grendler, 'Printing and censorship', in *Cambridge History, cit.* (n. 1), pp. 25-53, on p. 46.
8 Westman, *art. cit.* (n. 4), p. 82.
9 Charles G. Nauert, Jr., 'Humanists, scientists, and Pliny: changing approaches to a classical author', *American Historical Review*, 84, 1979, pp. 80-1.
10 Marie Boas Hall, *Nature and Nature's Laws: Documents of the Scientific Revolution*, New York, 1970, p. 74 (from Thomas Salusbury's translation of 1661).
11 With the most notable exception being fiercely independent Venice; Galileo was offered asylum there when called to trial in Rome in 1632: Giorgio de Santillana, *The Crime of Galileo*, Chicago, 1955, p. 208.
12 Owen Gingerich, 'The censorship of Copernicus' *De revolutionibus,' Annali dell' Istituto e Museo di Storia della Scienza di Firenze*, 7, 1981, pp. 45-61.
13 Shea, *art. cit.* (n. 5), p. 132.
14 Grassi translated in Pietro Redondi, *Galileo: Heretic*, Princeton, 1987, pp. 335-6.
15 *The Philosophical Writings of Descartes*, trans. John Cottingham, Robert Stoothoff and Dugald Murdoch, 2 vols., Cambridge, 1984, II, 152-3.
16 John L. Heilbron, *Electricity in the 17th and 18th Centuries: A Study of Early Modern Physics*, Berkeley, Los Angeles, London, 1979, p. 102.
17 There were variations in the curricular structure between colleges and over time; this is the curriculum at the college of La Flèche when Descartes and Mersenne were there: Peter Dear, *Mersenne and the Learning of the Schools*, Ithaca, 1988, pp. 12-13; Heilbron, *op. cit.*, pp. 101-2.
18 William A. Wallace, *Galileo and His Sources: The Heritage of the Collegio Romano in Galileo's Science*, Princeton, 1984, pp. 282-4; Westman, *art. cit.* (n. 4), p. 101; Christophorus Scheiner, *Rosa ursina sive sol*, Bracciano, 1630, p. 690 and *passim*. A letter of 1634 by the Jesuit Athanasius Kircher suggested that Scheiner, among others, would have been a Copernican if not for the condemnation: Santillana, *op. cit.* (n. 11), pp. 290-91.
19 Wallace, *op. cit.*, p. 147 n. 156 and p. 269. Scheiner, on the other hand, was, like Grassi, a Jesuit who had little personal affection for Galileo.
20 Peter Dear, 'Jesuit mathematical science and the reconstitution of experience in the early seventeenth century', *Studies in History and Philosophy of Science*, 18, 1987, p. 174; Stillman Drake, 'Impetus theory and quanta of speed before and after Galileo', *Physis*, 16, 1974, pp. 47-65.
21 Heilbron, *op. cit.* (n. 16), pp. 180n., pp. 133-5.
22 James R. Jacob, *Henry Stubbe, Radical Protestantism and the Early Enlightenment*, Cambridge, 1983, p. 86: the argument was used in 1670 as the pretext for an attack on the Royal Society.
23 Michael Heyd, *Between Orthodoxy and the Enlightenment: Jean-Robert Chouet and the Introduction of Cartesian Science in the Academy of Geneva*, International Archives of the History of Ideas, 96, The Hague/Boston/London, 1982, 'Conclusion'; L. W. B. Brockliss, *French Higher Education in the Seventeenth Century and Eighteenth Centuries: A Cultural History*, Oxford, 1987, pp. 345-50; Charles Webster, 'Puritanism, separatism, and science', in *God and Nature, cit.* (n. 4), pp. 192-217, esp. pp. 209-10.