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Science in the Church

The Argument

A brief review of the Merton thesis shows that its restriction to England is arbitrary. An example from the historiography of modern physics suggests the possible payoff of an ecumenical Merton thesis and the means to explore it. A summary of the careers of men who practiced science literally in the church – men who built meridian lines in Italian cathedrals – indicates the range of social support of astronomical studies by Catholic institutions in the seventeenth and eighteenth centuries.

There is nothing in the structure of Merton's thesis on the relationship among science, technology, and religion that restricts its application to Restoration England. This structure – which ranks almost as an analytic truth – is that science and technology will not flourish without widespread social approval and support. In the early modern period, organized religion was probably the leading former and formulator of social attitudes and aspirations. Therefore the flourishing science and technology of Restoration England had the support of the established church. It happened to be Protestant.

Science and technology also did well on the Continent in the seventeenth and eighteenth centuries. The Continent was predominantly Catholic. Therefore the Catholic church must have provided social support and approval for the cultivation of science and technology. It is my purpose to make this evident corollary of the Merton thesis plausible.

To fix ideas and to provide further rationale for a wider approach, I begin with a summary of Merton's thesis. Next, I offer a parable of glancing relevance to the effect that an ecumenical Merton thesis might give greater satisfaction than its Puritanical original. Third, I outline a hundred people-year research project to set the basis of the ecumenical thesis. Finally, I illustrate some points about the ecumenical approach by describing a variety of astronomy peculiar to Italy, which was to turn great cathedrals into pinhole cameras; and which mixed inextricably the useful and the sublime, or what we might be tempted to call applied and basic science. I pick

Italy as the natural setting for a Catholicized Merton thesis, and the cathedral observatories as the most literal available example of "science in the Church."

On Merton

Merton's thesis – which, stripped to essentials, is that Puritanism encouraged the spread of science and technology in England during the late seventeenth century – rests on three demonstrations.[1] One concerns career development. By counting in (and on) the *Dictionary of National Biography* and the discoveries listed in Ludwig Darmstaedter's *Handbuch zur Geschichte der Naturwissenschaften und Technik,* Merton found that more Englishmen interested themselves in science, and made more discoveries in it, in the second half of the seventeenth century than in the first (Merton [1938] 1970, chaps. 2–3). A second demonstration is what might be called innocence by association. Merton located the primary cause of the quickening of English interest in science in a Puritan ethic, which instilled self-reliance, concern with public welfare, admiration of God's handiwork, sobriety, hard work, confidence in reason and experience, concern with the practical and applied – in short, a dozen virtues useful to a scientist or an engineer (cf. Greaves 1969). As Puritanism gathered strength in Britain, so too did social support for science. Identification with the reigning religion removed the ethos and methods of science from the list of socially subversive activities; hence, innocence by association (Merton 1970, chap. 4).

Merton's third demonstration employed comparative numerology. If the enlargement of the scientific enterprise was a consequence of a social reinforcement provided through Puritanism, Protestant countries ought to have made greater contributions to science than did Catholic ones. Scattered numbers supported the comparison. The Royal Society of London has had more Protestant than Catholic foreign members, although the total Catholic population of Europe has outnumbered the Protestant. In 1875–76, in Prussia, a larger proportion of Protestant than of Catholic children went to secondary school; the Catholics that did go concentrated in the classical gymnasium, whence many sublimed to theology, whereas the Protestants preferred the more practically oriented *Realschulen*. Between 1539 and 1825 in France, Protestants were represented among men of letters three or four times as frequently as they were among the population at large; and the Protestant writers concentrated more on scholarship, and less on belles lettres, than did their Catholic counterparts. The Scottish and the Irish fell out the same way, the one taciturn and good at science, the other outgoing and good at poetry (Merton 1970, 128, 132–35). All of this is ingenious and suggestive, but of little direct relevance to the seventeenth century. In particular, Italy – the Italy of Galileo, Torricelli, Cavalieri, Grimaldi, Cassini, Borelli, Aldrovandi – does not appear at all.[2]

[1] This modest rendition is that preferred by Merton (1970, vii–xxix), and defended by Abraham (1983, 369, 373).

[2] Hooykaas (1977, 98ff.) is guilty of the same neglect, which has been noticed in the critical literature on Merton's thesis – e.g., Rabb 1965, 112–14, 117, 125.

Merton's attempts to demonstrate that Protestantism is more congenial to science than Catholicism won his book some critics. Whatever value the Catholic church put upon science in the seventeenth century, it purports to admire it in the twentieth, and some of its spokesmen, notably the Jesuit François Russo, undertook to best Merton in nose counting. Russo lined up a Catholic scientist for every Protestant offered by the other side, and he argued that the lineups themselves meant nothing if it could not be shown that the scientists had been inspired in their work by their religious beliefs (Russo 1956, 855–56, 863, 874–80). A study along Russo's lines would require posthumous interviews.

Another weighty difficulty may be urged against the statistics Merton brought to argue the relative importance of Protestantism and Catholicism for the progress of science. It is not plausible to attribute to differences in religious confession the difference in productive capacity for scientists of, say, Eastern European Catholic peasant populations and Western European mercantile communities. This point has been dilated by many writers (e.g., Mason 1950, 253–59). Is it commerce and industry or religion that should be taken as the primary factor? Merton developed his thesis about England so as to avoid the need to answer the question; indeed, he coupled the factors together by showing the emphasis on technology of the early members of the Royal Society of London (Hall 1963; Merton 1970, xii–xiii, chaps. 7–10). But as soon as he went comparative, he opened himself to the objection that religion cannot be the controlling factor. The Protestant populations of the British commonwealth have not produced as many scientists per capita as Britain; American Baptists have made a showing poorer still; Sweden fell from a major scientific power in the eighteenth century to a minor one in the nineteenth without changing its religion. On the Catholic side, Italy has done better than Spain and Eastern Europe, and far better than Latin America.

There remains innocence by association. Was there a natural and fruitful bond between Puritanism and science in seventeenth-century Britain? The issue has been obscured by squabbles over the meaning of "Puritan," by which Merton generously understood all non-Catholic Christians in the British Isles (Hall 1963, 3–6; Kearney 1964, 94–95; Kearney 1965, 104–10). I think he was exactly right about this innocence by association, even if he should have called Puritans Latitudinarians; and he might profitably have stopped there. The thesis might then have been that English science grew not because of the special virtues of Protestantism, but because the institutions and teachings of the dominant church gave it support. It does not follow that because this church was Protestant or Puritan, Catholic institutions offered less effective support. We arrive therefore at the ecumenical Merton thesis: where science prospered in early modern times, it derived important support and reinforcement from organized religion.

Another Approach

Merton's findings may be combined with a striking result from the historiography of recent physics to suggest a new approach to early modern science. Here is the result: around 1900, Britain, France, Germany, and the United States supported academic physics at the same level. The percentage of the populations engaged in physics and the fraction of national incomes devoted to physics in all four countries agreed to within two or three percent (Forman et al. 1975, 6, 10). This result is astonishing for at least two reasons. For one, the mechanisms of financial support varied considerably among the countries. In Britain, university endowments and private philanthropy carried the main burden; in France, the central government; in Germany, the state governments; and in the United States, the state governments and gifts from individuals and charitable foundations. The second surprise about the equality of effort is that it conflicts with the impression, derived from contemporary sources and retrospective analyses, that Germany then dominated physical science because of its larger investments in plant and personnel.

The equality of 1900 was fleeting. France could not sustain the effort and fell behind; Britain and Germany retained their positions; and the ever richer United States forged ahead. The historian wants to know the causes that first produced the unstable equilibrium and then upset it. Evidently the causes must be sought not only within the several countries but also, and most important, in their interactions: it is hard to understand how they could have reached equilibrium without a strong coupling among them. It does not take much insight to find the coupling in the spirit of international rivalry and opportunistic cooperation that also brought agreements on armaments, a balance in colonial acquisition, the sharing of markets, the establishment of the international postal and telegraphic unions, and the revival of the Olympic games. The physicists of the fin de siècle made good use of this spirit. British physicists observed that universities and *Technische Hochschulen* were to Germany what the fleet was to Britain and demanded government support. Germans recognized the challenge of the United States and sought ways to tap private money. Americans looked at Europe and clamoured for higher social status and greater resources for research. The French looked everywhere, saw the benefits of decentralization, and put a claim upon municipal governments.

Let us assume that at some time around the middle of the seventeenth century, Italy, France, and England were supporting science equally by the measures we have been considering. To be sure, it would be very much more difficult to demonstrate such a coincidence than it was to find the equilibrium in academic physics around 1900. In the latter case both the science and its immediate institutional setting were easily defined; in our case the application of the categories "science" and "scientific" is problematic at best, and the relevant institutions run from private collections to royal societies and established churches. Let us copy Merton's boldness, however, or what he calls the "uninhibited innocence of [his] youth" (Merton 1970, ix). Let us stipulate an equilibrium in scientific effort, that is, in the study of the physical world and the practical application of the lessons so learned, among Britain, France, and – what is as problematic a concept as "science" in the seventeenth century – Italy. We may date this equilibrium around the middle of the century on the strength of Merton's numbers about England, some qualitative information about the others, and the incidence of Catholic priests among the entries in the *Dictionary of Scientific Biography*.

The number of Catholic priests active in each half century from 1550 to 1750 as noticed in the *Dictionary* remains constant at just over thirty except for the second half of the seventeenth century, when it falls to twenty-two; whereas the fraction of scientists who were Catholic priests diminishes monotonically, from 23 percent during 1551–1600 to 9 percent during 1700–1750. It is plausible to infer that at the beginning of the seventeenth century Italy outdid Britain and France in the social support of science, and then slowed or stagnated while the others caught up.

To investigate this suppositious equilibrium, we must inventory the ways in which science was transmitted, studied, and improved in the several societies; its sources of financial and social support; and the international couplings implied by equilibrium. Obvious items in the inventory are schools and universities, together with their libraries and collections; other libraries, museums, and botanical gardens; the trade in scientific books and encyclopedias; the manufacture of instruments; sources of news about foreign discoveries; ways of procuring rare specimens; the roles of wealthy patrons, including the Church; the value placed upon science and scientific pursuits by dominant social forces; and the respect accorded to one country's scientific output by another.

There is already considerable literature on these subjects. Universities and colleges, particularly the colleges of the Jesuits, have received sustained attention. We know their faculties, their pedagogy, and in many cases their effective practices, as well as their statutory requirements. We also know much about contributions to mathematics and natural philosophy by the most famous professors. We know the names of almost everyone charged to teach mathematics in the Jesuit colleges of Europe for two hundred years (Dainville 1954; Fischer 1978; Fischer 1983); we read in the works of Francis Bacon that Jesuit education was the best available nursery for the investigators he wanted to grow (Heilbron 1979, 102); we encounter many people in the *Dictionary of Scientific Biography* who passed through the order's schools; but we do not know in any systematic way which or how many early modern scientists owed their initial formation to the Society of Jesus. Here the editors of the *Dictionary* missed a grand opportunity. Had they required their contributors to provide basic data about the education of all the people covered, we would have a beginning of the inventory we require. A similar opportunity was lost by Charles Paul (1980).

Libraries, observatories, and botanical gardens offer another sort of challenge to the systematizer. Derek Howse has published a valuable list of the observatories founded between 1670 and 1850, with indications of the dates of acquisition of their principal instruments (Howse 1986). At Berkeley, we have begun to compile a list of botanical gardens and their main sources of unusual specimens. There is much scattered information available about individual libraries, sometimes with indications of their scientific books. We must learn more about these collections, both public and private, and about their use and availability. In an age where patronage mediated a savant's career even more than it does today, private collections often played a decisive part in recruitment and research. Here we must not neglect the *Wunderkammern*, or collections of curiosities of art and nature. A love of elegant, unusual, and miscellaneous knickknacks – unicorn's horns, monsters, fossils, automata, lodestones, mappae mundi, telescopes, clocks, and so on – is not an infallible sign of a weak mind. Even Newton liked tall stories about nature's oddities (Heilbron 1983, 4). The museum and garden of rarities could not help but arouse interest in all but the dullest minds. No matter that the motive of the collectors might have been showing off or winning prestige; in fact all the better. The collections would have failed in their purpose – to excite admiration and emulation – if shut up as a private laboratory or work place (cf. Franchini et al. 1979, 80–86; Galluzzi 1980, 195–98).

This brings us to another function of these semi-private, clerical or laymen's museums. They were places where visiting and local scholars met to spread news of recent discoveries and review the state of the Republic of Letters. Sometimes experiments might be shown in these museums. Thence it was but a small step to the small, private, scientific academy, maintained by a prince or dignitary of the Church. The Florentine Accademia del Cimento is perhaps the best known of these; but there were many others, in Naples, Rome, Bologna, Brescia, and smaller places (Heilbron 1979, 107, 184–89; Heilbron 1983, 8, 13–15; cf. Casciato et al. 1986 and Tavernari 1976). Historians have tended to consider academies as distinct in kind from collections, observatories, and museums, perhaps because of the rhetoric and reputation of the members of the royal societies of London and Paris; but the circumstances of the founding of these societies, and their early practices in conducting and witnessing experiments as a group, disclose the connection clearly. The interlocking pieces may be seen to particular advantage in the Institute of Art and Science of Bologna. It brought together private groups that had cultivated mathematical sciences and fine art and provided collections of naturalia, books, and instruments in an environment that encouraged both teaching by demonstration and experimental research (Heilbron in press).

The production and distribution of books are scarcely fresh subjects of historical inquiry. Much information is available that we might exploit as indices to the social and financial support of science. Then as now, big monographs on technical subjects cost much to produce and sold poorly. Subventions were necessary; their sources should be a chief object of our study. The dedications of the volumes are an obvious place to start. They will bring in a motley set of Maecenases. We know from the correspondence of Athanasius Kircher, whose huge, illustrated folios had high production costs, that a well-placed Jesuit could lay all sorts of people under contribution, including Protestant princes (Heilbron 1979, 112–13; Fletcher 1986b, 284–85). This is a capital point. The willingness of the wealthy to contribute to the cost of production of expensive books approved by the Church helped to cancel adverse effects of the censorship through which the books had to pass. Scientific books were seldom prohibited, although they might be delayed, by the Congregation of the Index; and the eventual imprimaturs no doubt helped authors raise money from the pious and wealthy.

One of the most expensive and, for our purposes, indicative early modern publications was the encyclopedia. That a compendium of knowledge carries with it and enforces a world view was not a discovery of Diderot and d'Alembert. During the seventeenth century, Protestant and Catholic compilers vied to organize the rapidly increasing knowledge about the natural world and to dump it into minds they hoped thereby to influence. Here again the Jesuits were especially effective (Vasoli 1986, 62–63; Ianniello 1986, 234). They had much up-to-date information from their missionaries abroad and from their learned correspondence with all Europe. They gave their most vigorous scholars time to organize it all and to combine it with the wisdom and knowledge heaped up in their libraries. Some of the resultant compendia, such as G. B. Riccioli's on astronomy, were standard reference works for Protestants as well as Catholics. Gaspar Schott's great inventories of curiosities played a similar role: they contain the first description of the air pump invented by the Protestant Otto von Guericke and many excellent diagrams of other instruments and machines (Fletcher 1986a, 133–34; Bedini 1986, 256–63; Keefe 1966, 47–54; Heilbron 1979, 105–7).

The inventorying of academic physics around 1900 took three historians two years; the projects I have just outlined would take ten historians a decade, if they planned out the work together carefully and had sufficient research assistance. The individual scholar defines problems that will yield to individual effort. The approach works well for intellectual history and biography; but it cannot gain the sort of quantitative and systematic data needed to establish benchmarks in comparative social and institutional history. The possibilities opened by the computer, which permits experiment with connections and parallels that would be impossible to try by hand, further recommend a group effort on the ecumenical Merton thesis.

Some Indicators

A resumé of the careers of a few early modern scientists will illustrate the institutional workings that our ecumenicists will study. To avoid arbitrariness without losing scope, and to remain as far as possible from the well-travelled byways of England, I have chosen as my careerists everyone who perforated a large Italian church in the interest of exact science from the end of the sixteenth to the end of the eighteenth century. I mean "perforate." These men obtained permission from the custodians of sacred buildings to open permanent holes in the walls or domes to admit the light of the sun; and also permission to embed long metal rules encased in marble in the floors, to catch the solar rays. The rule or *meridiana* ran precisely north south; its intersection with the moving image of the sun's disk marked local noon;

and its size made possible the detection of such delicate effects as the dependence of refraction on altitude, the seasonal alterations in the speed and distance of the sun, and the secular change in the obliquity of the ecliptic. These last quantities, being fundamental to positional astronomy, were the common targets of the investigations of people who could not agree whether the sun went round the earth, or the earth went round the sun. I shall neglect the perturbation of the lives of early modern astronomers caused by disputes over world systems.

The following table lists the builders of the several *meridiane* in chronological order. The strength of the clerical tie is not surprising in an enterprise that amounted to the peaceful transformation of a church into an observatory; of greater interest are the routes by which the builders came to their tasks.

Table. Major *Meridiane* Built or Rebuilt in Italy, 1575–1800

Date	Place	Church	Builder	Niche
1575	Bologna	S. Petronio	E. Danti	Dominican
1656	Bologna	S. Petronio	G. D. Cassini	Professor, academician
1701	Rome	S. M. degli Angeli	F. Bianchini	Sinecurist
1755	Florence	Duomo	L. Ximenes	Jesuit, professor
1786	Milan	Duomo	G. A. Cesaris	Jesuit, astronomer
1801	Palermo	Cattedrale	G. Piazzi	Theatine, astronomer

The earliest of them, Egnazio Danti, started up the ladder of patronage as a functionary at the court of Cosimo I of Florence and ended as a bishop and adviser of popes. His assets were a knowledge of astronomy and geography, a good sense for art and for politics, and a brother retained by Cosimo as a painter. On the recommendation of the brother, Cosimo brought Danti, already a Dominican, to Florence as his "cosmographer" to help plan geographical murals for the antechamber of his wardrobe. That was in the early 1570s, when the problem of reforming the calendar was coming to a head.

Cosimo liked to think of himself as a modern Julius Caesar. Danti proposed to cast himself in the role of Sosigenes, Caesar's astronomical adviser, and to anticipate what became the Gregorian reform of the Julian calendar. To obtain precise information about the occurrence of the equinoxes, Danti cemented instruments on the façade of the Church of Santa Maria Novella; and when these proved inadequate, he punched a hole high up on the wall, to act as an ocular for a meridian line inside. Cosimo died before the work could progress, however, and there rose up a Caesar who knew not his Sosigenes. After a year in relative eclipse, Danti was thrown out of Florence. He landed in Bologna, then a part of the Papal States, as professor of astronomy at the ancient university. There, in 1575–76, he had the satisfaction of setting out a *meridiana* between the piers sustaining the nave of the huge Church of San Petronio (Bonelli and Settle 1979; Badia 1881, 12–20).

This piece of work and admiration of the wardrobe maps gained Danti the patronage of one greater even than Caesar, namely the pope. Gregory XIII put Danti on the commission to reform the calendar; he commissioned him further to plan a series of maps for the Galleria del Belvedere in the Vatican palace and to decorate the Tower of the Winds just completed in the Vatican gardens. Danti's maps, still a high point of a visit to the Vatican, were an important contribution to cartography. His decoration of the Tower included an accurate meridian line on which, according to tradition, Gregory observed the discrepancy between the sun's position and the Julian reckoning, which strengthened his conviction of the need for reform. For his trouble and achievement, Danti was elevated from professor to bishop. He no doubt would have proceeded further and become a patron of art and science himself, had he not been called prematurely to a better world (Badia 1881, 22–25; Stein 1950).

Danti's *meridiana* in San Petronio ran a little off true, partly because of the location of the piers. In 1656 his successor in the Bologna chair of astronomy took advantage of an enlargement of the church to squeeze a better and longer line into the restricted space (fig. 1). This precise performer, Gian Domenico or Jean Dominique Cassini, became the leading astronomer of the late seventeenth century. After completing his education at the Jesuit college in Genoa, where he developed an interest in mathematics, astronomy, and astrology, Cassini moved through an infrastructure critically important for the support of science but very difficult to inventory retrospectively. He spent some time at an abbey, whose abbot had an interest in applied mathematics. There he attracted the attention of a nobleman, Cornelio Malvasia, who had set up a little private observatory in Modena. Cassini transferred his activities to Modena,

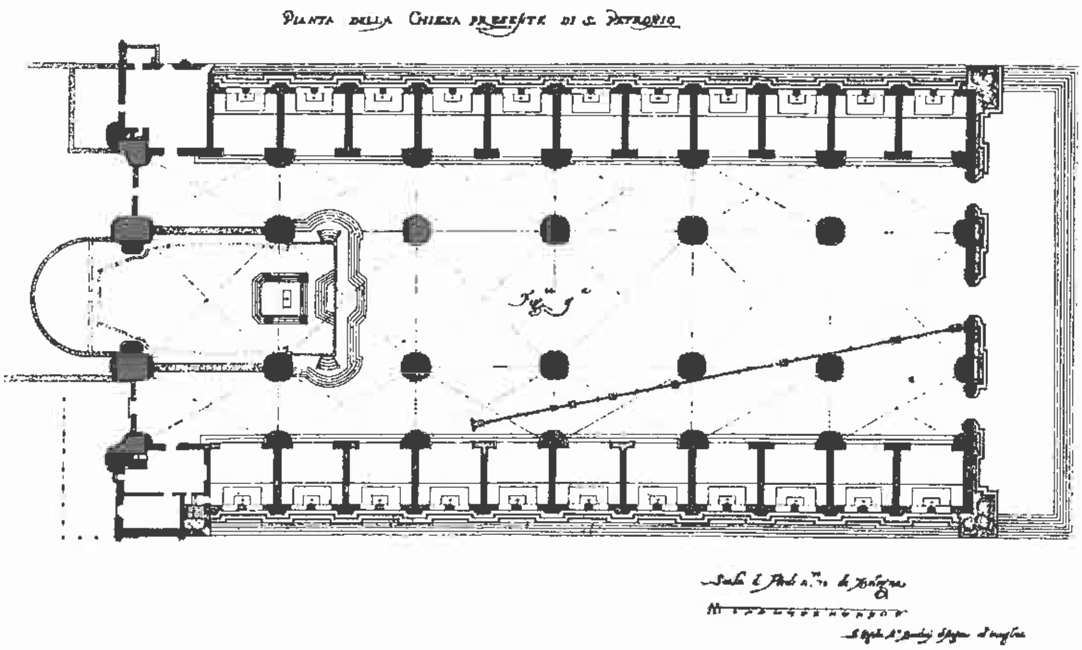

Figure 1. Floor plan of San Petronio in Bologna, showing the *meridiana* touching two piers of the nave as it runs toward the main entrance of the church, near which the sun's image falls on the day of the winter solstice. From Cassini 1695.

where he learned to use up-to-date instruments and profited greatly from the instruction of two other visitors, the accomplished Jesuit astronomers Riccioli and Grimaldi, whose base of operations was Bologna. Through their influence and Malvasia's, Cassini obtained his chair in astronomy in 1650, at the age of twenty-five (Fontenelle 1740, 1:274–76; Grillot 1987, 146–47).

At Bologna, Cassini made himself famous by compiling tables of refraction, by calculating the times of eclipses of Jupiter's satellites (an important aid to the determination of longitude), and above all, by laying out the *meridiana*. His primary purpose, which he realized, was to construct an instrument that would provide more exact information than any otherwise procurable about the effects of refraction and the distance of the sun. The pope desired to have such an ornament as Cassini in his service; as Fontenelle, the official necrologist of early-modern science, observed in his notice of Cassini, "so subtle an astronomer is almost a prophet."

The pope offered Cassini many preferments if he would become a cleric. Now Cassini was a man of unusual piety and faithful observance. And he understood fully the potential of the link between his profession and his religion. He once wrote about the utility of astronomy in spreading the gospel in words that perfectly described his own situation: astronomy enables missionaries "to live not only in security, but also in entire freedom to preach the truths of the faith, to win the admiration of the people, to insinuate themselves into the company of the great, and even to gain the favor of sovereigns." Nonetheless Cassini declined the pope's offer. Fontenelle guessed at the reason and estimated the loss: "The temptation was great; in Italy a learned ecclesiastic can reach a rank where he can claim to be scarcely inferior to kings; there is no other station with such opportunities; but M. Cassini did not feel the calling, and the very piety that made him worthy of entering the Church kept him from it" (Cassini 1730, 51–52; Fontenelle 1740, 287; cf. Wolf 1902, 72).

Cassini was perhaps the more willing to surrender these opportunities since his university and also the king of France, then building a huge observatory, were also bidding for his services. He decided on France. The new observatory provided a perfect opportunity for the exercise of his penchant for spectacular instrumentation. He wanted to turn the building itself into an instrument, by redesigning it so as to contain a huge *meridiana*; but the floor he wanted had already been completed, and he had to content himself with something much more modest than San Petronio. He also promoted the use of telescopes with objective lens of very long focal length, which revealed finer detail than the smaller achromatic lenses the next century would bring, but at very considerable capital and operating costs. Figure 2 shows the logistical problems of maneuvering long telescopes even on calm days; one did not observe in the wind.

In 1695 Cassini visited Bologna en route to Rome. Calendar reform was being agitated again: Easter as calculated from the Gregorian canon would miss astronomical Easter, as determined from Kepler's tables, by a week in 1700 and by a month in 1724. The *meridiana* in San Petronio might have something to contribute after all to the purpose for which Danti had first placed one there. With the help of the

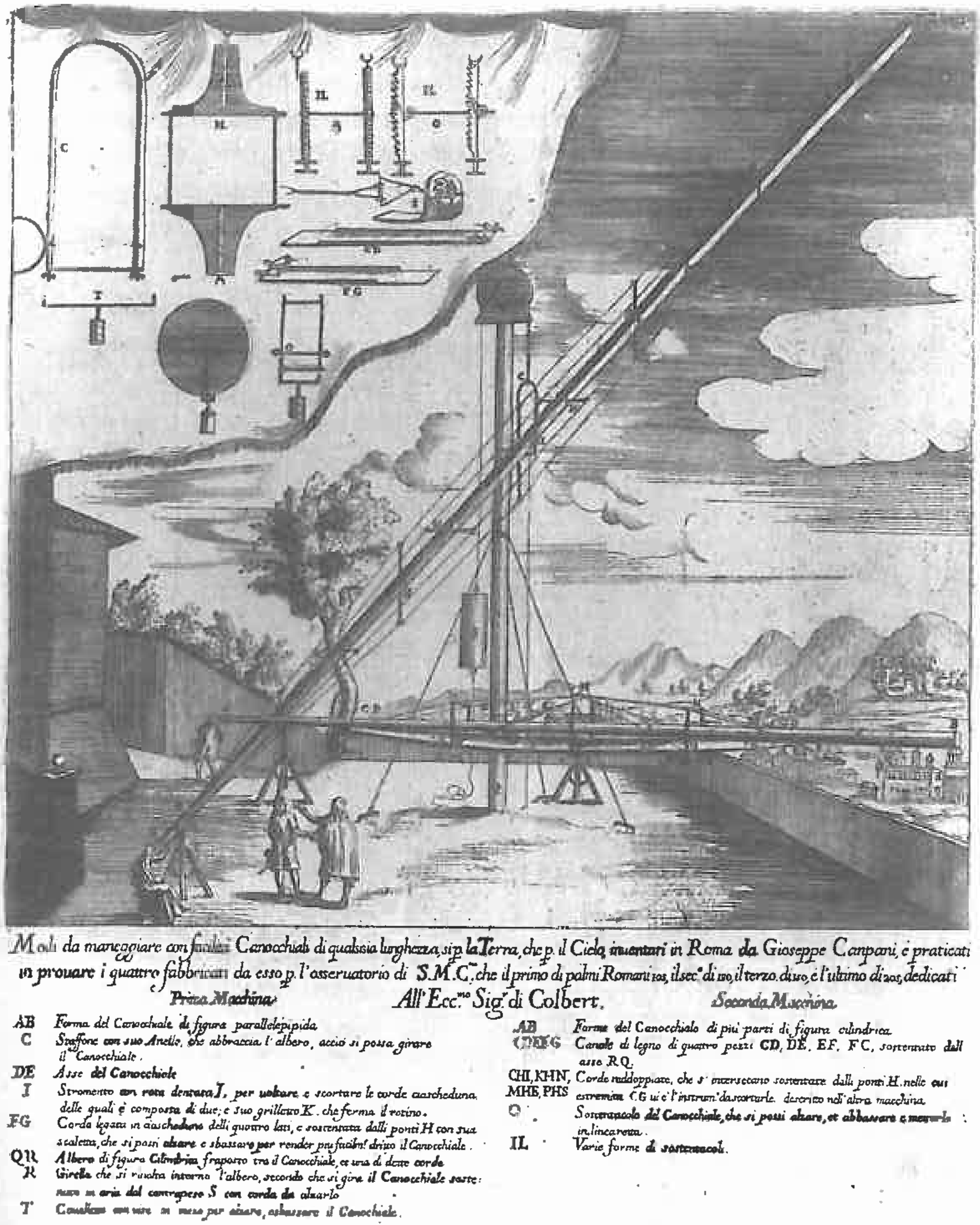

Figure 2. "Ways of handling telescopes of any length easily." From Bianchini 1728.

incumbent professor of astronomy, Cassini reset and releveled the instrument, which functioned as a solar observatory until well into the eighteenth century (Cassini 1695, 5–7).

The calendrical problem took on a new urgency in 1700, when the German Protestant states announced their intention of adopting the Gregorian reckoning in all particulars but the computation of Easter, for which they preferred the tables of their coreligionist Kepler. The reigning pope, Clement XI, hoping to head off this mini-schism, set up a commission on the calendar to which he appointed his chamberlain, an antiquarian and astronomer named Francesco Bianchini, who also received the charge of placing a *meridiana* in the Church of Santa Maria degli Angeli (fig. 3).

Bianchini had followed a more complicated path than his older friend and inspiration Cassini through the infrastructure of science in Italy in the later seventeenth century. After his education at the hands of the Jesuits, he attended the University of Padua, where he assisted the professor of astronomy. In 1684, aged twenty-two, Bianchini went to Rome, intending to pursue an ecclesiastical career; instead he became librarian to Cardinal Pietro Ottobroni, to whom he had an introduction through an uncle. This occupation left him ample time for his astronomical studies and for attending the physical-mathematical academy around Monsignor Giovanni Giustino Ciampini (Middleton 1975). In 1689 Bianchini's cardinal became pope. We are told that the librarian was among the first to render homage. "Bianchini, what do you want now that we are pope?" the new man asked. "Your blessing," was the reply. Bianchini got that, and also a canonry, two pensions, and the job of librarian to the papal nephew, also Cardinal Pietro Ottobroni. In working his way through the Ottobronis' library, Bianchini became an erudite historian as well as a practiced mathematician (Alberti-Poja 1949, 14–16; Fontenelle 1740, 2:398–409).

Under the next pope, Bianchini took minor holy orders and picked up a canonry. "Had he become a priest," his biographer conjectures, "who knows how high in the hierarchy he would have risen?" He did well enough as a deacon. Clement XI made him *cameriere d'onore,* put him in charge of all antiquities in Rome, sent him on confidential missions, and gave him still another canonry and dues from ecclesiastical holdings in Sardinia (Alberti-Poja 1949, 17–25; Mazzuchelli 1760, 1167–69). Bianchini put much of the varied income that he derived from the Church into his historical, astronomical, and geographical research. He was both the grantor and grantee on many research projects, which included preliminary measurements along the *meridiana* of longitude from Rome to Rimini later mapped by Boscovich, and careful observation of the surface appearances of Venus. In these last researches, reported in a sumptuous book underwritten by the king of Portugal (who received in return the naming of Venusian features after Portuguese heroes), Bianchini used expensive long telescopes of the type popularized by Cassini (Bianchini 1728). As appears from Figure 4, Bianchini had support, both figurative and immediate, from the Church in these observations. The literal dependence of the telescope on the heavens suggests an investigation of the iconography that renders science safe. As a

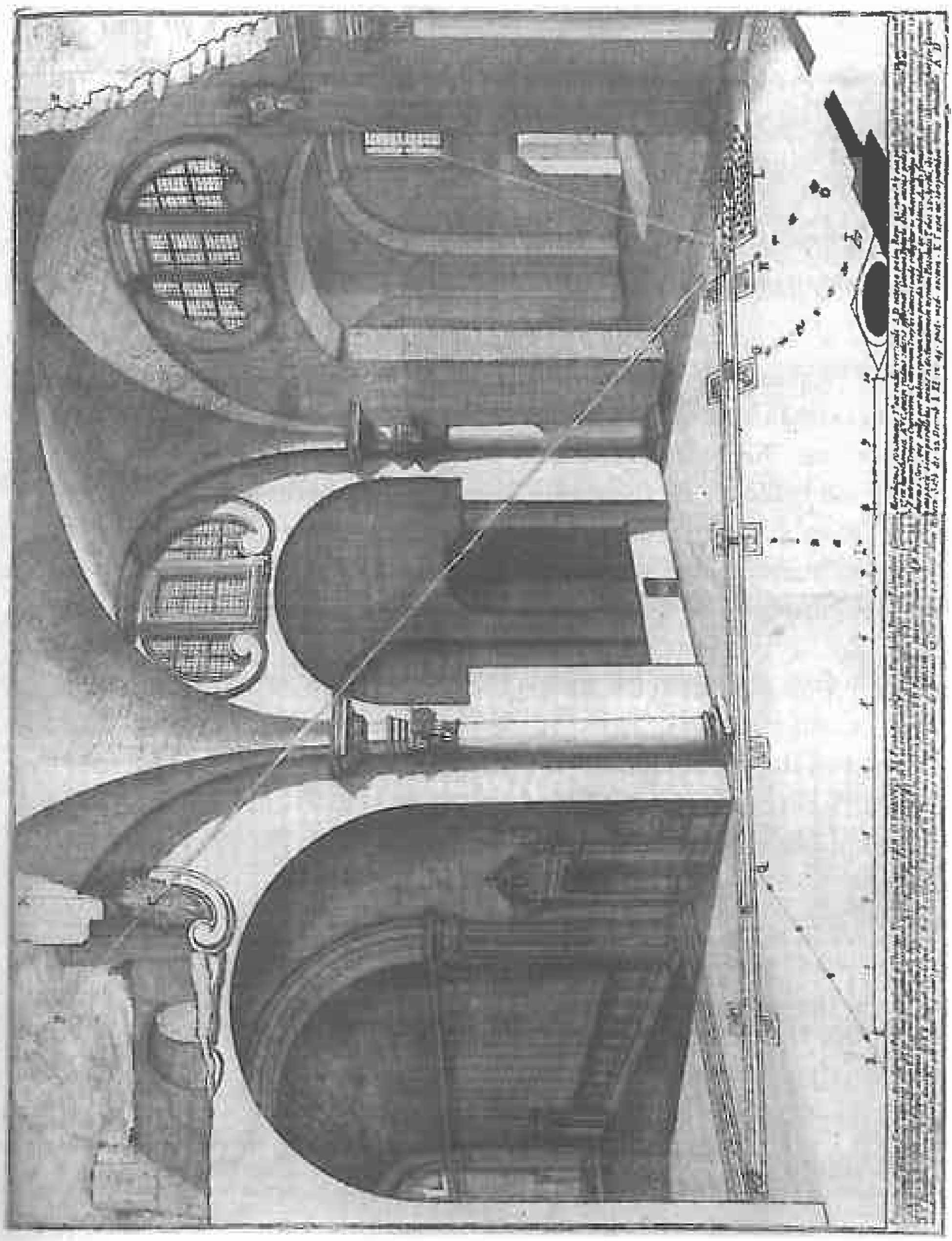

Figure 3. Santa Maria degli Angeli, Rome, showing, to the right, a beam from the midsummer sun and, from the left, a line to Polaris. The series of concentric ellipses LM indicates the diurnal rotation of the pole star at 25-year intervals beginning in 1700; a pretty demonstration of the results of the precession of the equinoxes. The line QR indicates the diurnal motion of Sirius; GY, the trace of the sun's image on the day that Pope Clement came to inspect the meridian. **From Bianchini 1703, after p. 12.**

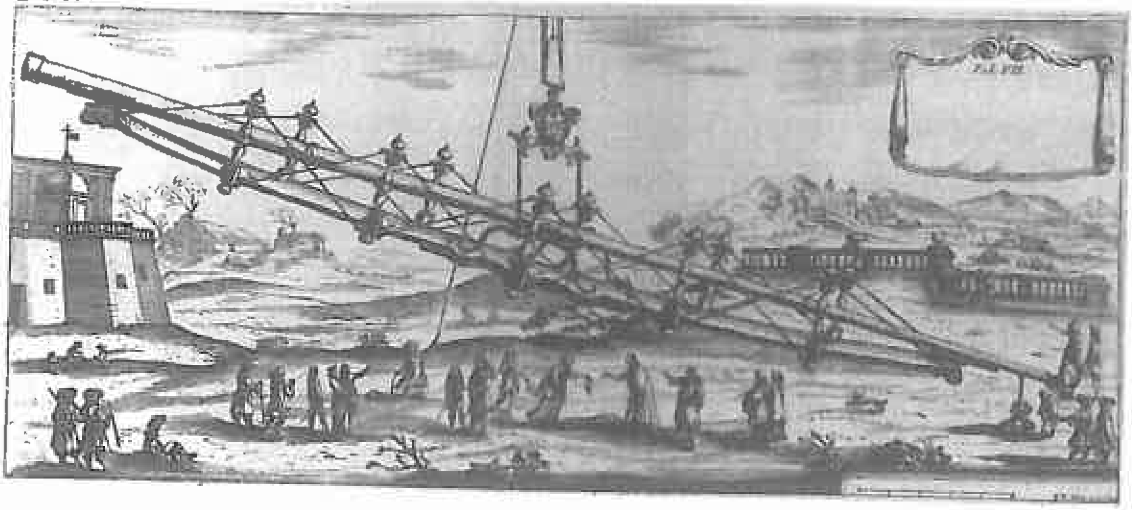

Figure 4. An aereal telescope suspended by faith. From Bianchini 1728.

further contribution to this new subject, the true manner of discovery of Galileo's law of falling bodies, as illustrated by a maker of *meridiane* (fig. 5), may be in order.

The careers of the builders of the *meridiane* in the cathedrals of Florence and Milan had fewer twists and kinks than Bianchini's or Cassini's. Both builders were Jesuits and Jesuit-educated. That does not mean that they followed the same path. Leonardo Ximenes, though attached to the Jesuit house in Florence for much of his career, was a professor and applied mathematician in the style of Boscovich: he advised about the repair of church buildings, the canalization of rivers, the draining of marches, and so on.[3] His first steps are reminiscent of Bianchini's. A Sicilian trained at Trapani and Rome, Ximenes was called to Florence on the initiative of the Marchese Vincenzo Riccardi, who applied to the Jesuits' Roman provincial for someone to teach mathematics to his sons. The tutoring left Ximenes time for his own studies in astronomy and geography, which he pursued in the libraries of the Riccardi and the Florentine Jesuits. His first public works, proposed in the early 1750s, centered on an exact map of Tuscany to be based on precise determinations of degrees of longitude and latitude crossing in Florence; but he did not obtain enough grand-ducal support beyond the titles of imperial geographer (1755) and royal mathematician (1766) to accomplish the project (Barsanti and Rombai 1987, 27–30, 38–40).

The setting of the *meridiana* in the Duomo was a part of the geographical plan. Ximenes aimed to use the cathedral both as the center of his cartographical grid and as an instrument of solar physics. His was a work of supererogation. Ximenes worried about the effects of the evaporation from his water level during the work, about the flexure of measuring rods under their own weight, and about the diffraction of light at the hole; he read his barometer and thermometer up and down the church; he

[3] Palcani 1790, x, xvi; Boscovich to Arnolfini, February and March 1781, in Arrighi 1963, 57–62; Barsanti and Rombai 1987, 14–22, 46–95.

counted the beats of pendulums on the floor and on the roof; in short, he made his big book on the *meridiana* of Florence a text of the best practice of the quantitative physics of the Enlightenment. The main astronomical result of his assiduity was a confirmation of the secular change in the obliquity of the ecliptic and an estimate of its value that erred by 50 percent (Ximenes 1757, 87, 103, 200–220, 235–84; Ximenes 1776, 7–19).

Giovanni Angelo Cesaris made his way into the Jesuit college of Brera in Milan directly after entering into his novitiate in 1764. There he became an assistant at the observatory. He stayed on when the Brera came under imperial rule in 1772, just before the suppression of the Jesuit order, and remained throughout his career. He observed long and hard, celebrated mass daily, did little that was original, and left, as his finest monument, a long meridian line parallel to the façade of the Milanese Duomo (fig. 6). When this line was installed in 1786, *meridiane* had long since been superseded for accurate measurements by quadrants fitted with lenses (Gabba 1957; Passano et al. 1977, 9–20). Cesaris' rule showed the Milanese the time of noon for the accurate setting of their pocket watches. That was also the purpose of the *meridiana* placed in the cathedral of Palermo about 1800 by the Theatine priest and astronomer Giuseppe Piazzi (Gabba 1921, 447; Ramelli 1965, 144; Cacciatore 1824).

Piazzi's career was similar to but more distinguished than Cesaris'. After completing his studies, Piazzi taught in several Italian cities before receiving an appointment in 1780 to a chair in mathematics at the former Jesuit college in Palermo. The viceroy of Sicily strongly supported Piazzi's wish to establish there what would be the southernmost observatory in Europe. With instruments obtained from England, including a magnificent five-foot quadrant, Piazzi surveyed the stars from a tower of

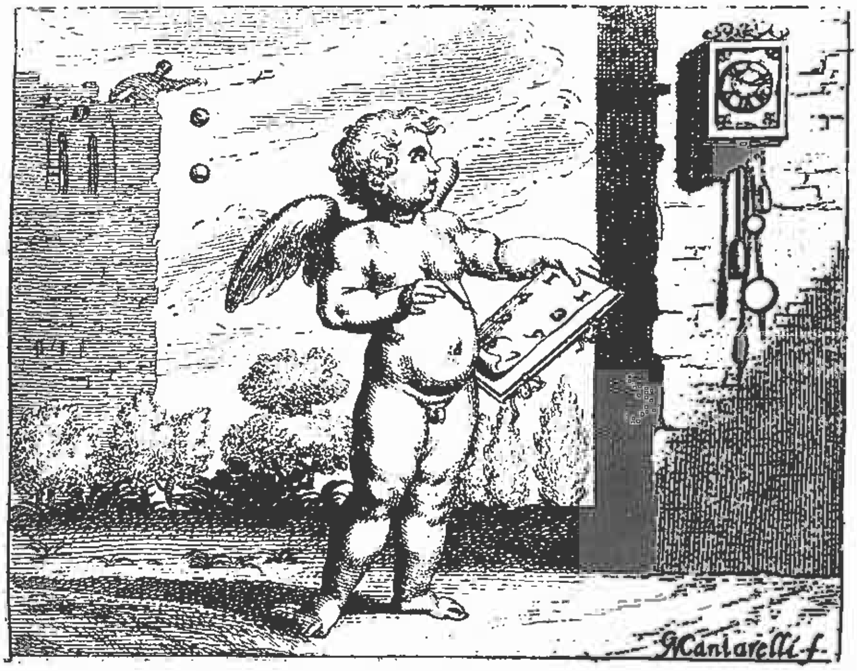

Figure 5. An angelic research assistant confirms Galileo's law of falling bodies. From Manfredi 1736, p. 95.

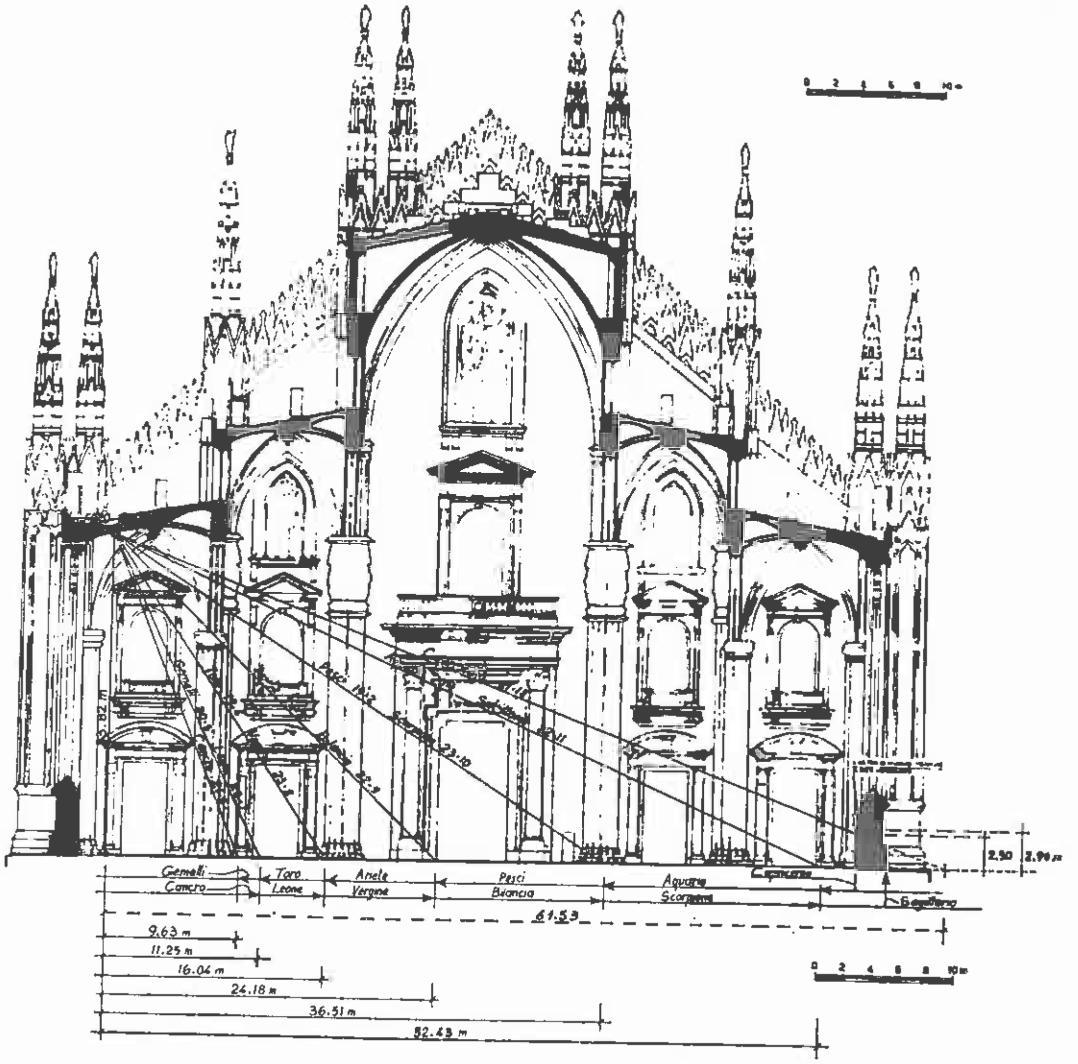

Figure 6. Façade of the Duomo of Milan, showing the location of the *meridiana* and the positions of the sun's noon image on the days on which it enters each of the zodiacal signs. From Passano, Monti, and Mussio 1977, p. 42, by kind permission of the publishers.

the royal palace in Palermo. He put out a more accurate catalogue of stellar positions than any previously published, and he found, among much else, the first of the asteroids between Mars and Jupiter (Angelitti 1925).

The careers of our several *meridiane* makers indicate the richness and complexity of our task. Above all, we must examine the patterns of patronage that gave people the opportunity – it might be better to say that induced or recruited them – to devote their time to the study of the natural world. This patronage turned on early modern society's interest in art and geography; on the Church's need for applied mathematicians; on a positive evaluation of the creation of new knowledge; and on a widely diffused curiosity about rarities of art and nature. In the special case of the *meridiane* makers, the patrons included great princes such as the grand duke of Tuscany, the king of France, and the pope; lesser aristocrats like the marquis of Malvasia and the cardinals Ottobroni; religious orders; and leading universities and colleges. The niches into which patronage might thrust the rising scientist were scattered over a wide terrain: cosmographer, architect, designer, librarian, superintendent of antiquities, hydrographer, academician, sinecurist, university professor. Many of these positions were supported by the Church; all had the general approval of the wider society in which the Church played a dominant role.

This is not to say that another method of support might not have produced more scientists and also better ones. But the historian is interested in societies that have existed, not in those that might have been; and the historian of science should not be put off the study of one scientific culture because another might have raised a larger number of scientists. A related point is that most scientists are not great scientists. From the milieux that the majority creates, however, sports of art and nature such as a Galileo and a Newton sometimes arise. It behooves us to attend to the circumstances that created the productive milieux. Individual historians working alone will not get far. We need an international institute for the prosecution of ecumenical Merton studies. The patrons of our institute are not far to seek. The agencies that organized the 1988 Merton workshop have already shown themselves to be friendly to the enterprise; and they have the further merit that they can scarcely be suspected of favoring one Christian church above another.

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