Science and Humanism in the Italian Renaissance

ERIC COCHRANE

Some five decades ago, in the heat of the revolt against the Burckhardtian view of the Renaissance, science and humanism were generally regarded as antithetical, or at least as completely unrelated historical phenomena. In chapter 66, Volume IV, of his monumental History of Magic and Experimental Science—a chapter appropriately entitled “Humanism in Relation to Natural and Occult Science”—Lynn Thorndike noted that, except for occasional references to astrology, only a few of the well-known representatives of quattrocento humanism ever wrote anything on subjects that might be considered scientific. Of these, Pier Candido Decembrio gave “a derivative and amateurish performance” in the single one of his some 127 works that strayed from the narrow path of philology and rhetoric. Similarly, Galeotto Marzio merely paraphrased Peter of Albano in the De Incognitis Vulgo that he addressed to Lorenzo the Magnificent; and his “miscellaneous rambling” happily led him rapidly on to subjects in which he was more qualified—like the efficacy of prayer and the intercession of saints. Thorndike could not but conclude that “the fifteenth century strikes us as distinctly inferior to the fourteenth” in all of the sciences except perhaps surgery and anatomy; and he suggested as a possible cause for this decline the draining off of Italian talent into what he called “humanism and painting.”

Thorndike’s thesis was supported at the time by the contribution of the pioneer of modern studies in ancient science, George Sarton, to a symposium published just a few years earlier with the intentionally Burckhardtian title of The Civilization of the Renaissance; and it was corroborated some twenty years later by Sarton’s lectures on several Renaissance scientists. Science, said Sarton, has been introduced into Western culture not once but twice: first in the twelfth century, with the translation of Arabic mathematic and scientific texts, and second in the seventeenth century, in the course of what became

A revised version of a paper originally presented at the seventh annual conference of the Center for Medieval and Renaissance Studies at the Ohio State University in February 1976.

1 Lynn Thorndike, History of Magic and Experimental Science (New York, 1934).
known as the “Scientific Revolution.” But whereas after its second appearance science succeeded in becoming a permanent part of Western culture, soon after its first appearance it was swept away by its antithesis, that is, by Italian humanism. For humanism turned the minds of prospective scientists from fact to form, from substance to grammar, from empirical investigation to the adoration of ancient authorities. True, Sarton admitted, a few humanists showed signs of appreciating at least scientific methodology: Leonardo, Pico, and Machiavelli. But Leonardo hid his writings from his contemporaries. Pico died prematurely. Machiavelli proved unable “to emancipate himself from the vanity and corruption of his environment.” And all of them were thoroughly forgotten by those who were to reintroduce science in the age of Galileo and Descartes.

The views of Sarton and Thorndike fitted very well with views current at the time concerning other aspects of Renaissance culture. The political historian Ferdinand Schevill insisted that creativity in the realm of politics came to an end at the beginning of the fifteenth century. It was then, he said, that the “guild democracy” of the medieval communes finally succumbed to plutocracy and dictatorship, while the vernacular language in which communal political activity had been expressed gave way to classical Latin, a language intelligible only to an elite. Similarly, the economic historian Armando Sapori insisted that as an economic phenomenon the Renaissance collapsed in the bank crashes of the 1340s and that the chronological period which Burckhardt had assigned to the Renaissance actually coincided with a long-term economic depression and a series of demographic catastrophes. Indeed, Robert Lopez subsequently established a causal relationship between the collapse of Sapori’s Renaissance, which David Herlihy has now documented with statistics, and the advent of Burckhardt’s Renaissance, which Lopez has defined as a purely cultural phenomenon. These theses were also supported, at least negatively, by those historians of philosophy who simply skipped, in their histories of European philosophy, over the two centuries between the nominalists and Descartes; and those few, like Ernst Cassirer, who tried to fill in the gap with such names as Nicholas of Cusa, Marsilio Ficino, and Giordano Bruno, described an intellectual movement that admittedly led not to the physical world, but beyond it.

Indeed, the views of Thorndike and Sarton were at least consonant with what had been and what were then the leading interpretations of the Renaissance as a whole. Burckhardt himself had admitted “the defects in his

---

4 See Delio Cantimori, “Il problema rinascimentale proposto da Armando Sapori,” in his Studi di storia (Turin, 1959), 966–78.
5 David Herlihy, Medieval and Renaissance Pistoia (New Haven, 1967).
knowledge on this point," and he implied by his selection of examples that the most obvious manifestation of Renaissance science consisted in the collection of strange plants and animals for the amusement of pleasure-seeking princes. Burckhardt’s successors in the 1930s and 40s as the authors of the most provocative definitions of the Renaissance, Benedetto Croce and Federico Chabod, identified as its most characteristic innovation the recognition of the autonomy of certain disciplines, notably political science and esthetics. But none of these disciplines had anything to do with what came to be known as science. And since they in turn lost their vitality, at least in Italy, long before the appearance of Galileo, they could have contributed nothing to the scientific work of the age which Croce isolated from the Renaissance under the title “Baroque.”

All that was needed to make these theses wholly credible was to overcome their sole remaining defect: that of isolating Galileo from a historical context. This task was performed by J. H. Randall, who discovered a direct link between Sarton’s first and second scientific ages in the University of Padua. Padua, Randall pointed out, remained faithful to Aristotle and Averroes throughout the two centuries in which the rest of Italy was taken over by grammarians and Platonists. Moreover, it succeeded in separating philosophy from theology and in uniting it with the most experimental of the then accepted academic disciplines, medicine. Under the protection of “the leading anti-papal and anti-clerical” state of the period, the Republic of Venice, it provided Galileo with a noble lineage of nonhumanistic forefathers, from Giovanni Marliano and Ugo Benzi da Siena to Agostino Nifo and Giacomo Zabarella. The Paduan philosophers, Randall observed, developed a “combination of the resolutive and compositive methods”; and they set forth a “clear statement of the procedures” that were to be adopted by the seventeenth-century scientists. Since these philosophers were all Aristotelians, he could not but conclude that “the father of modern science” was none other than “the Master of Those Who Know.”

That Renaissance humanism had nothing to do with, and that it even thwarted or delayed, the birth of modern science, is a thesis that can easily be documented by passages in those humanist texts that have attracted the attention of recent scholars. If humanism begins with Petrarch, as is often held, then it bears the indelible mark of Petrarch’s appropriation of Augustine’s and Cicero’s negative judgment of Hellenistic science. “Of what relevance is it to know a multitude of things?” asked Petrarch in the Secretum. “Suppose you shall have learned all the circuits of the heavens and the earth, the spaces of the sea, the course of the stars, the virtues of herbs and stones, the secret of nature, and then be ignorant of yourself?” After a two-minute
glance at the Alps and the Rhone, Petrarch recalled Augustine’s admonition: “And men go to admire the high mountains, the vast floods of the ocean, the huge streams of the rivers . . . and desert themselves.” Accordingly, all his followers for the next two centuries followed him down from Mt. Ventoux, which, as Sarton reminds us, is only a little over 6,000 feet high. If, on the other hand, humanism really begins with Coluccio Salutati and Leonardo Bruni, as Hans Baron maintains, then obviously it is concerned exclusively with establishing a new relationship between man and society and between the past and the present. What counts, for Machiavelli, Guicciardini, Gasparo Contarini, and Donato Giannotti, as well as for Bruni, is how man can control not the natural world but the human world.

Even less interest in science is to be found in the works cited to support the recent variants of Baron’s definition—of those, namely, which identify humanism as a series of temporary incarnations of such eternal categories as “Republicanism” or “The Machiavellian Moment.” Neither Paolo Paruto nor Niccolò Contarini had anything to say about anatomy, biology, and geography at a time when Venetian printers were making good money publishing books under such titles. Indeed, they were staunchly opposed to the kind of incipient scientific agriculture that was just then attracting the investment capital of so many backsliding refugees from maritime commerce in their day. That the founder of natural science in Italy preferred to live under a regime which represented the very antithesis of “republican” freedom, that his most enthusiastic disciples were monks rather than merchant patricians, and that he himself was scrupulous about adhering to the liturgical formulas of the current incarnation of the medieval, hierarchical, antirepublican principle, the Counter-Reformation Church—all this merely proves once again the incompatibility of humanism and science, and it makes the latter the daughter not of Florence, but of Rome, not of the secular, but of the religious mentality of the age.

Meanwhile, those few humanists who had once been admitted to the ranks at least of the protoscientists, and those protoscientists who had been admitted to the ranks of the humanists, were expelled either from one or the other or from both. In the light of Eugenio Garin’s recent additions to his still-standard biography, Pico della Mirandola can now be given credentials in science only to the extent that he was willing to read the works of the Paduan philosophers—those, that is, who, according to Randall, transmitted the scientific heritage of the Middle Ages. For the function Pico assigned to natural philosophy would have been unacceptable both to the Averroists and

10 From Book II of Secretum and Familiares, IV:1, in Petrarch, Prose (Milan, 1955), 68 ff. and 830 ff.
12 Eugenio Garin, Giovanni Pico della Mirandola, vita e dottrina (Florence, 1937); and more recently, “Ricerche su Giovanni Pico della Mirandola,” in La cultura filosofica del Rinascimento italiano (Florence, 1961). The correspondence with Ermolao Barbaro on this point is published by Garin in Prosatori latini del Quattrocento (Milan, 1952), 805 ff.
to Galileo. Its purpose, he insists, is to “allay the strife and differences of opinion which vex, distract, and wound the spirit from all sides,” and therefore to prepare its adherents to approach its “mistress,” “holiest theology,” one step up on Jacob’s ladder. Paolo Toscanelli too had studied at Padua and had learned to apply mathematics and astronomy to the practical necessities of his mercantile firm at Pisa. But what he himself considered his major acquisition at the university was the friendship of the mystical neo-Platonist Nicholas of Cusa. And what he was best known for in Florence in his day was his participation in the moral, philosophical, and literary conversations at Camaldoli recorded by Cristoforo Landini. According to Garin, indeed, it was the humanistic “climate” of his native city that prevented him from becoming a Paduan natural philosopher; and it is not surprising that his calculations were more often put to the service of fantasy and prophesy than to what was recognized as science at Padua.

Hence, Pico and Toscanelli have become humanists, not scientists, and they have been put firmly in the same category with Ficino and Poliziano, not in that of Ugo da Siena. Leonardo, on the other hand, turns out to have been a scientist, not a humanist. According to Carlo Pedretti, who is responsible for much of the recent increase in the available original texts, Leonardo owed his scientific interests, and hence his innovations even in the art of landscape painting, to “the Aristotelian teaching of the school of Padua,” which, Pedretti thinks, he must have heard about during one of his trips to Venice. According to Manuzio Romano, a hospital director as well as a historian of medicine, and Pamela Taylor, editor of the current English translation of the Notebooks, Leonardo was “an absolutely a-historical figure”; and he owed these scientific interests to his own “insatiable curiosity,” which alone was capable of breaking through the “medieval darkness of his time.” According to Raymond Stiles, who has apparently mastered the new art of “psychohistory,” he owed them partially to his boyhood observations of the peculiar natural environment of his native village and partially to his own individual psychological makeup. And according to all of these authorities, he owed nothing whatsoever to the human and cultural environment of his adopted city.

Thus historians may well be justified in accepting the distinction between humanism and science proposed in the 1540s by Sperone Speroni—who, almost alone among his contemporaries, happened to be both a humanist and

---


14 Garin’s biography of Toscanelli is most readily available in *La cultura filosofica del Rinascimento italiano*, and in English translation in his *Portraits from the Quattrocento* (New York, 1972).


The essence of humanism is rhetoric, said Speroni. Rhetoric seeks to persuade by reference to what appears to be true (verosimile), while science seeks to establish what is in fact true (vero). One uses probable arguments. The other uses logically binding arguments (argumento apodittico). One promotes the moral improvement (ammaestramento) of all men in the political order of the terrestrial city. The other serves the solely intellectual interests of “those who contemplate the eternal nature of being” in the “celestial city.” Hence the two are completely separate compartments of the human mind.19

Unfortunately, this extension of Speroni’s distinction to the problem of the origins of modern science in Italy has been challenged recently by several new, and to some extent unexpected, events in the realm of historical scholarship. The first event is the elimination of the late medieval nominalists from their role as precursors of Galileo. The nearest that anyone has come (to my knowledge) in trying to reassert that role is Gibellato Valabrego with his observations on the similarity of certain of Galileo’s statements about mathematics to certain others buried under what Valabrego calls the “scholastic subtleties” of Nicholas Oresme’s Quaestiones super Geometriam Euclidis. But since Oresme’s text was discovered only in 1951, Galileo could not have found it among the works of the Parisian doctors he supposedly read in his youth.20 The similarities, therefore, are purely fortuitous—which is what Anneliese Meier long ago held to be true of all the other similarities that were once cited as evidence of direct borrowings.21 Some authorities may still insist, like A. C. Crombie, “that Aristotle had a profound influence on Galileo’s scientific thought.”22 That, after all, is obvious to anyone who has read the Dialogue on the Two Systems of the World, where Aristotelian cosmology is fully explained. But even Marshall Clagett now admits that medieval mechanics wrecked itself before Galileo proposed a new mechanics to take its place.23 And not even Crombie denies that there was some substance in the acrimonious anti-Aristotelianism, if not of Galileo himself, then certainly of Galileo’s followers, from Marco Aurelio Severino in Naples24 to the academicians of the Cimento in Florence. Apparently, then, whoever persists in looking back to Paris or Oxford for the progenitors of Galilean science must now be dismissed as the victim of what John Murdoch calls the ailment of “precursoritis.”25

The second event is the accession to Randall’s position of Bruno Nardi and Cesare Vasoli. Aided by several able students of the history of logic, Nardi

---

19 See Cesare Vasoli, Studi sulla cultura del Rinascimento (Manduria, 1968), 264 ff.
and Vasoli are now the leading authorities on the school of Padua. Notwithstanding certain similarities, Vasoli says, Paduan Aristotelianism, and particularly the Aristotelianism of one of its most illustrious representatives, Nicoletto Vernia, was wholly incompatible with Galilean philosophy. It was so first, because of its insistence upon such un-Galilean doctrines as the eternity of the world, and second, because of its categorical exclusion from philosophy of "any practical function" and of "any compromise with the inferior reality of the human world." What interested the Paduans, insists Vasoli, and consequently what interested the Pisans, the Pavians, the Neapolitans, and all the other local representatives of what he has shown to have been a single Italian academic community, was not what nature was, but what Aristotle said it was. And thanks to the availability of the original texts both of Aristotle himself and of his Hellenistic commentators, they were very successful in pursuing that interest. But differences of opinion over just what Aristotle meant and over the relative value of his Hellenistic and Arabic commentators in elucidating his meaning soon divided the Aristotelians into opposing camps; and the resulting divisions were exacerbated by rivalries for academic chairs, by an increasing violence of language, and by varying preferences for one or the other of Aristotle's works as the basic text in logic. The century opened with the fight between the orthodox Averroist Marcantonio Zimara, whose appointment at Padua Pietro Bembo tried to block, and the Alexandrines Alessandro Achillini and Pietro Pomponazzi, who accused Averroes of having plagiarized Simplicius. The century ended with Zabarella's largely unwarranted attack upon Girolamo Balduino, from whom he lifted many of his main theses, and with the attack upon Zabarella by the "Platonizing" Aristotelian Francesco Piccolomini and by Piccolomini's contentious pupil, Bernardino Petrella.

To be sure, this quarreling stimulated a plethora of ingenious speculation, some of which in turn produced theses that bear a striking resemblance to those of Galileo—Balduino's reduction of logic to an "art" and Zabarella's identification of logic with the operation of the physical world. It even, on occasion, produced a positive evaluation of inductive, as opposed to deductive, reasoning that at least paralleled the positions of such anti-Aristotelian logicians as Rudolph Agricola and Peter Ramus. But the similarities have turned out, on closer examination, to be purely fortuitous. Far from freeing it for eventual application elsewhere, the separation of philosophy from theology and then from metaphysics simply sterilized it—or, in the words of Antonino Poppi, "closed it in the old forms of bookish learning isolated either from experimental observation or from the mathematical formulation of objective data." Hence, it can in no way "be considered as an immediate precursor of [the work of] the Pisan scientist."


27 Antonio Poppi, La dottrina della scienza in Giacomo Zabarella (Padua, 1972).
Its association with medicine had a regressive rather than a progressive effect, for it trapped the physicians in the “dogmatic naturalism of the Galenists” against which the first of the real moderns, Vesalius and Fabrizio of Acquapendente, rose in rebellion—as A. Corsano noted in 1962. Hence, “it cannot possibly have contributed in any way to Galileo’s great methodological revolution.” Even Zabarella’s distinction between demonstratio quia and demonstratio propter quid remained firmly anchored on the syllogism, and it was aimed not at establishing the veracity of new knowledge, but solely in “restoring the classical and medieval structure of science.” It represents, therefore, not the beginnings of a new science, but “the farthest possible development” of a science which, having reached “the last step in its evolution, . . . had already exhausted itself.” “The thesis of a continuity between . . . the Peripateticism of the Cinquecento logicians . . . and the methodology of modern science,” concludes Giovanni Papuli, “must be completely rejected.”

Apparently, then, the only contribution to modern science that can still be attributed to the Paduan Aristotelians is that of having laid bare all the inherent weaknesses and contradictions of the Aristotelian cosmos just at a time when it was becoming ever less compatible with an ever-increasing body of empirical data. For over a hundred years they had managed to put up with what Shlomo Pines has shown to be the cosmological implications of Ptolemaic astronomy. For some fifty years they had managed to ignore the forceful, if rather obscurely stated, cosmological theses of Copernicus. But by 1600 the old cosmos had been so thoroughly explored, and its principles had been so soundly shaken by recent observations in biology (for example, Andrea Cesalpino), in anatomy, and above all, in mechanics and astronomy, that it collapsed, in Nardi’s words, “like a house of cards” the moment Galileo thought fit to subtract from philosophy the task of “saving the phenomena.” It is thus not surprising, as Angelo Crescini has shown, that Galileo’s act provoked the unanimous hostility of all the Aristotelians of all persuasions. Nor is it surprising that they expressed their defenselessness by resorting to force—by appealing to political and ecclesiastical authority in order to censure Telesio, to condemn Galileo, and to break up the new order of the Scolopians, who had dared teach Galilean physics to school children. By the middle of the seventeenth century there was nothing left of one productive school of Paduan Aristotelians but the tiny group of aristocratic “Libertines” whom Lorenzo Magalotti at the time and Giorgio Spini more...
recently have decried as the chief agents of "decadence" in the Age of the Baroque.\(^{32}\)

The third event is the appearance of a new interpretation of what has hitherto been considered, at least in the writings of Alexandre Koyré, the only serious rival to Paduan or Parisian Aristotelianism in their claims upon Galileo's ancestry: Platonism. According to this new interpretation, the final product of Platonism, or rather of the Neo-Platonism that issued from the translations and commentaries of Marsilio Ficino, was not Galilean science. It was rather the magnificent, grandiose cosmological systems excogitated by the great metaphysicians of the late sixteenth century, of which those of Telesio, Patrizi, Bruno, and Campanella are well known in the English-speaking world through the essays of Paul Oskar Kristeller.\(^{33}\) Like the Aristotelians, the metaphysicians too occasionally came up with theses that sound Galilean—most notably those of Bruno concerning the infinity of the universe and the heliocentric structure of the solar system. But such theses were wholly un-Galilean. For they were based on metaphysics, on logic, or on magic, not on observation and mathematics; and they were held together by love, or by what Frances Yates calls "magical animation," not by laws.\(^{34}\) Hence, the first contribution of Renaissance Platonism to the rise of Galilean science now appears to have consisted in reinforcing the impression, by its proposal of alternatives, that the cracks in the Aristotelian cosmos had grown so wide as to make it unsalvageable. That, in any case, is Paul-Henri Michel's explanation of the violence with which Bruno rejected all he had learned as a disciple of the Aristotelian Dominicans—and of the lay Aristotelian university professor Balduino—at Naples.\(^{35}\) The second contribution consisted in suggesting to Galileo the cosmological implications of his particular studies in mechanics and astronomy. That, at least, is Garin's explanation of the Ficinian language in Galileo's letter of 1615 to Pietro Dini. This suggestion led Galileo to go back beyond the speculations of the metaphysicians to the cosmos of Copernicus, which he, unlike Bruno, was able to understand. What he found turned out to be as different from the Platonic cosmos as it was from the Aristotelian—and, better yet, with the aid of the telescope it turned out to be amenable to empirical verification, as Bruno's, according to Hélène Védrine, most certainly was not.\(^{36}\)

These contributions were then unwittingly furthered by the bungling Holy

---

32 Giorgio Spini, Ricerca dei Libertini (Rome, 1950). All the current (to 1973) bibliography on Magalotti, and on the Florentine Galileans mentioned below, is listed in the bibliographical note to Book IV of my Florence in the Forgotten Centuries (Chicago, 1973).
Office bureaucrats who thwarted the publication of Patrizi's *Nova de Universa Philosophia* in the 1590's, about which Luigi Firpo has written at length. For in deliberately discouraging the excogitation of still another metaphysical, qualitative, animate cosmos, they prepared the way for the replacement of all of them by a mathematical, quantitative, material cosmos, one which had the distinct advantage (as Galileo pointed out in his letter to the grand duchess) of guaranteeing theologians immunity from the theses of the physicists. The difference between the new cosmos and all its predecessors was evident to the antimetaphysical academicians of the Cimento in the 1660s, when they fell asleep while Orazio Rucellai read to them from his interminable Neo-Platonic dialogues. And it is just as evident to the modern reader of the descriptions of each of them presented in a symposium published in 1970 with the title *L'Univers à la Renaissance*. As Thomas McTighe concluded succinctly, "Galileo was no Platonist. He was his own man." True, two new ways of saving Platonism for science have recently been proposed. The first is to turn the metaphysicians into something called "empiricists" and then to make Platonism into an atemporal football, one which can be passed from "men like Ficino and Pico" (who therefore becomes a Platonist) directly into the hands of the Cambridge Platonists. The second is to incorporate Platonism into something called "Rosacruceanism," which, because of its cryptic nature, can be attributed to almost everyone during the two centuries after Leonardo. But the first way skips the Galileans entirely. And the second still lies buried in certain "vast sleeping tomes"—tomes of which Frances Yates suspects the existence, but which have unfortunately escaped the notice of the diligent editors of the *edizione nazionale* of Galileo's complete works.

The most disturbing consequence of these three historiographical events is that they have once again left Galileo isolated from a historical context. In isolating Galileo, moreover, they have also disinherited the whole productive and multifarious school of science in seventeenth- and eighteenth-century Italy—a school which, alas, is still known only through a few scattered monographs. For the members of this school, whatever may have been their particular specialization, all derived either directly or indirectly from Galileo—the Accademia del Cimento, which was founded by Galileo's immediate disciples in Florence, the Accademia degli Investiganti of Naples, which was converted from Campanellian to Galilean science by Giovanni Antonio Borelli, and the "unbroken series of students" who, according to Luigi Belloni, passed Galileo's methods on from Borelli's disciple Malpighi to the generation of Morgagni. Worse yet, the whole of the Italian Enlightenment, to

---

which so much study has been dedicated of late, has been divested of what Croce once established as its bond with the Renaissance. Since the Enlightenment began as a rebellion against the literary and juridical aspects of current Italian culture, that bond could be provided only by the scientific aspects, as the eighteenth-century literati themselves admitted in giving to the Galileans the credit for having saved Italian literature from the assaults of the Marinists. If the Galilean heritage can now be traced no further back in time than to Galileo himself, then even the conscious effort of Italians in the age of Muratori to revive the poetry, piety, and historiography of the age of Della Casa, Sigonio, and the Council of Trent, must be attributed solely to cultural stimuli from abroad. And that is an attribution which few historians would any longer wish to sustain.

One way out of this dilemma, certainly, is to ignore it—which seems to have happened at the international symposium on Galileo held at Florence in 1964. Another way is to revert to a genius theory of historical causality, something like the one Giorgio Vasari used to explain changes in art styles from Giotto to Michelangelo. But since neither of these ways is particularly consonant with the professional obligations or the acceptable methodological premises of modern historiography, only one way remains—namely, to explore once again the relation between Galileo and the first generation of Galileans on the one hand and, on the other hand, what had been the dominant element in Italian culture for the preceding two centuries. This is the way proposed by one of the leading authorities on Italian humanism, Eugenio Garin, in the essays included in the volume translated into English as Science and Civic Life in the Renaissance. It is the way indicated by the recent students of Italian art and literature, who have at last filled the chronological gap left by Chabod's definition of the Renaissance between the generations of Machiavelli and Galileo. It is also the way suggested by the Galileo specialist Stillman Drake and by the authority on all Renaissance science, Marie Boas Hall, in her still indispensable survey, The Scientific Renaissance.

To be sure, it still cannot be said that humanism was specifically scientific in any of its successive stages. Man, and what man made, remained the principal object of humanistic investigation. Philology remained the principal method by which such investigations were carried on. And rhetoric, that is, the manner in which the results of the investigations were expressed, remained quite as important as the results themselves. Nevertheless, it may now be possible to say that humanism facilitated the birth of Galilean science—at least in providing the particular forms assumed by the scientific revolution in

Italy. It may be possible to say, in other words, that Galileo differed from Kepler and Descartes, that Torricelli differed from Boyle, and the Cimento differed from the Académie des Sciences to the extent that they were more directly the heirs of the humanists.

First of all, humanism from the very beginning was hostile not to the kind of science later represented by Galileo, but rather to the very kind he did so much to overthrow. When Petrarch laughed at those of his contemporaries who pretended to know "about birds and fishes, about how many hairs there are in the lion’s mane, how many feathers in the hawk’s tail, how elephants couple from behind and are pregnant for two years," etc., etc., he was rejecting the botany and zoology of Vincent of Beauvais and Alexander Neckham, not botany and zoology as defined by the contemporaries of Francesco Redi; and he did so for the same reason that made the academicians of the Cimento laugh at Athanasius Kircher: that such knowledge was copied uncritically from unreliable authorities and could not be verified through observation. When Leonardo Bruni denounced the "Britannic sophisms" of the "modern philosophers," he did so not only because the sophisms had nothing to do with his two major concerns, ethics and politics, but for the good Galilean reason that they had been made into ends in themselves. By distinguishing debate for the sake of debate from discussion for the sake of acquiring knowledge and identifying error, the humanists emphasized both the moral and the scientific shortcomings of standard academic practice in their day. What they questioned, in other words, was the value of debates like the one at Pavia in the mid-sixteenth century, where Girolamo Cardano boasted of having "silenced my opponent on the very first day, in the very first proposition, even in the judgment of all my rivals." For the purpose of such debates was merely to furnish further evidence for the proposition: "Neither at Milan, nor at Pavia, nor in France, nor in Germany, have I ever found a man who could successfully controvert or dispute me within the last twenty-three years." And consequently the actual question posed to the debaters was so insignificant that Cardano did not bother to mention it. It is not surprising, then, that students at Pisa in the 1570s, most of whom arrived at the university after a thoroughly humanist preparation in Florence, attended the debates only to be amused—and only when they had time left over after banqueting, carousing, and putting on comedies.

Second, while it was not antithetical to a science based on reason and experience, humanism was positively receptive to technology. To be sure, the technological innovations of the fifteenth and sixteenth centuries were not dependent upon humanism. As Eugene Rice has shown in the first chapters of

---

47 From De Sui Ipsius et Multorum Ignorantia, in Petrarch, Prose, 712–14.
49 According to Filippo Sassetti in the first letters published in his Lettere edite e inedite, ed. Ettore Marcucci (Florence, 1835). This attitude of the students does not seem to reflect what Giovanni Cascio Pratilli finds to have been the transformation of the Tuscan universities into departments of the state: L'università e il principe: Gli studi di Siena e di Pisa tra Rinascimento e Controriforma (Florence, 1975).
his *Foundations of Early Modern Europe*, they were rather the products of the economic and social conditions of the commercial and industrial cities of the late Middle Ages, and they were often accomplished by artisans who had little or no knowledge of humanism. Yet in at least one city—namely, in the city in which both were the most productive, Florence—humanism and artisan technology developed side by side throughout the fifteenth century. Occasionally they met in the same person. They met first in Brunelleschi, whom Leon Battista Alberti admired equally for his technological and artistic achievements. They met most spectacularly in Leonardo. And Leonardo, thanks to Vasoli, can now be put back into history—not as a magician or as a proto-Rosicrucian, but as the most illustrious representative of two of the most important components of early Renaissance culture, the humanist and the artisan.50

The contact between these two currents became ever more frequent in the sixteenth century, when technology was formally fused with esthetics. What made Brunelleschi a great artist, said Giorgio Vasari, was not only his substitution of classical for “German” forms. It was also his success in constructing a snack bar on top of the cathedral of Florence, thus preventing the masons from descending to the street, on company time, whenever they got hungry or thirsty. What made the Last Judgment a great painting was in part Michelangelo’s invention of new ways of painting on plaster and of reconciling unity and variety. What made Benvenuto Cellini’s Perseus a great statue—according to Benvenuto himself—was partially its incorporation of a new way of casting in bronze. And, in Galileo’s own day, what made Pietro Tacca’s equestrian statue of King Philip III acceptable as a work of art was almost entirely the sculptor’s success in getting the horse to rear up on its hind legs and stay there, while its apparent center of gravity hung over a void.

Even more important, humanism provided technology with a theoretical framework, one which could give universal meaning to particular, practical innovations. It did so above all by making available the mathematical and scientific works of classical antiquity, and, more important still, by explaining and elucidating these works in such a way as to make them comprehensible, as they never had been in antiquity, to what T. S. Kuhn calls the “*honnête homme*.”51 As the mid-sixteenth-century campaign to popularize humanism gradually turned artisans into humanists, they too began to collaborate with those whom Vasoli calls “mathematician-philologists of humanist formation” in producing a long series of practical technical manuals, from Giacomo Aconcio’s *De Methodo* to the *Quesiti et inventioni diverse* of 1546 and the *General trattato di numeri et misure* of 1556. These manuals sought to explain the particular cases supplied by the artisans in terms of general theorems supplied by the

---


mathematicians.\textsuperscript{52} They thus elevated technology to the rank of philosophy, as it never had been in the schools. And Greek mathematics, which, according to Salomon Bochner, had been “slow, awkward, clumsy, bungling, and somehow sterile”\textsuperscript{53} in antiquity, was now endowed with the potential for practical application. Mathematics permitted an invention in one field to be transferred to another—for example, to the art of fortification, which John Hale\textsuperscript{54} has shown to have been one of the principal achievements of Italian Renaissance architects. It also permitted the transferal of a mathematical expression from the realm of art to the realm of physics—from a rule of perspective in painting to a new solution to a pressing problem in ballistics.

Thus the true ancestors of Galileo turn out to have been on the one hand the artisans who helped him build telescopes, and, on the other, the practical mathematicians—such as Ostilio Ricci, who was employed in Vasari’s Florentine Art Academy, and Federico Commandino, who was employed by the duke of Urbino to apply what he learned from the mathematical texts he was translating to the problems referred to him by the duke’s military captains. For it was the practical mathematicians who prepared the way for what, according to Paolo Rossi, was the most important innovation of Galileo: the union of technology and philosophy.\textsuperscript{55} This was the union that he forged in his workshop at Padua and that he celebrated in his famous panegyric of the Venetian Arsenal. Unlike their academic predecessors, the Galileans remained faithful to the very humanistic thesis that had made the union possible: the thesis that contemplation is valuable only to the extent that it arises from observation and only to the extent that it ends in action. Accordingly, while they gazed into the skies, they also manufactured scientific instruments, drained marshes, regulated river beds, and laid out seaports. And they applauded while the painters of the age of Giovanni da San Giovanni and Pietro da Cortona dissolved walls and ceilings into the infinite space of the Galilean cosmos.

A third major contribution of humanism to the rise of science consists in its destruction of the method of argument from authority. This destruction took some time to accomplish, to be sure. Even the Ficinian Platonists, who, after all, were excluded from the universities until well into the sixteenth century, continued to assume in their acceptance of the authenticity of the Hermetic writings a corollary to the principle of authority—namely, that all knowledge had once been achieved sometime in the distant past. Still, Petrarch had long before rejected most explicitly one of the most universal principles of medieval

\textsuperscript{52} Vasoli’s thesis (especially \textit{Profezia e ragione}, 499) is abundantly corroborated by the specific information on this subject provided by Alexandre Koyré in his contribution to René Taton, ed., \textit{Histoire générale des sciences} (Paris, 1957-61), vol. 2.


\textsuperscript{54} Among Hale’s numerous studies of this subject, see “The Development of the Bastion, 1440–1534” in John R. Hale, ed., \textit{Europe in the Late Middle Ages} (Evanston, 1965), 466–94.

thought. According to that principle, certain ancient authors (or rather every sentence written by certain ancient authors) were infallible within the particular disciplines assigned to them: Cicero in rhetoric, Augustine in theology, and, of course, Aristotle in logic, politics, metaphysics, et al. Petrarch reduced even his favorites among the ancients to the rank of men—men who might be right most of the time, but who, like Cicero in his letters to Atticus and in his treatise on the gods, could occasionally be wrong, ridiculous, and reprehensible. Machiavelli did the same to Livy. He accepted Livy’s word as long as he was narrating the deeds of the Romans. But he rejected it as soon as Livy stopped being a historian and tried to be a political philosopher as well.

This transformation of the ancients from a series of infallible statements or texts into individual, fallible, historically conditioned human beings could at times be somewhat disturbing. It placed upon modern men the complete responsibility for anything they might do or say. But it also solved the quarrel between the ancients and the moderns in Italy over a century before it broke out in France, as Hans Baron has shown. As Machiavelli expected Lorenzo de’ Medici to surpass the political achievements of Moses, Lycurgus, and Romulus, so Gaetano Contarini proved that the Venetians had already surpassed the Romans as constitution-makers, and Vasari proved that Michelangelo, as an artist, had surpassed all the ancients. Moreover, all of them believed that others in the future would surpass what the Venetian senators and Michelangelo had achieved in their own times. That meant that scientists were no longer bound by what one of their forefathers had said two millennia before. Thus Vesalius duly launched modern anatomy by breaking with Galen. And his innovation made such an impression outside strictly medical circles that it was celebrated by the humanist-painter Titian in a caricature of the Laocoön recently published by H. W. Janson. Janson’s discovery, by the way, is one more indication of the collaboration between artists and scientists during the century before Galileo. And it should be one more proof of the potential fruitfulness of collaboration between art historians and historians tout-court in the century we ourselves live in.

At the same time, the transformation of authorities into men multiplied the number of ancients who might have had correct answers. Who could now say that Aristotle was right when he disagreed with Democritus? And who could say that Ptolemy was right when he disagreed with Aristarchus? Moreover, this transformation gave the ancients a much more exalted role: that of proposing working hypotheses. As Polybius suggested to Machiavelli an alternative to Aristotle’s six forms of government, so the fragments of ancient musical scores discovered by Girolamo Mei suggested to Galileo’s father Vincenzo the possibility of substituting accompanied monody for polyphony.

Unlike authoritative statements, working hypotheses carried with them the injunction to try them out in practice: and it is in this sense that, according to William Shea, Galileo was a disciple of Archimedes. When the working hypotheses of the man Aristotle failed to solve the problem of motion, Galileo turned to the man Archimedes—not for an authoritative answer, but for an alternative working hypothesis, which he then assumed the obligation of testing. And Galileo’s disciples did likewise: while “testing and retesting,” according to the injunction of the Accademia del Cimento, the working hypotheses of the man they regarded as the greatest of all men but still a man, they considered themselves bound to modify or reject the hypotheses if they found them inconsistent with what they themselves observed with their microscopes and evacuated cylinders.

A particularly impressive example of the humanist campaign against the authority of the ancients is offered by the search for the philosophical foundations of literature, which, as Bernard Weinberg has shown, consumed so much of the energies of the Italian cultural world during the sixteenth century. This search began with Horace, for whom poetry must be judged in accordance with the expectations of the audience. It was then completely redirected, after the appearance of Alessandro de’ Pazzi’s translation of the poetics in 1536, toward Aristotle, according to whom the quality of a work of literature is a function of its internal structure and hence independent of rhetorical considerations. The first authority yielded to the next only after considerable resistance. Indeed, Francesco Filippi Pedemonte and Vincenzo Maggi went so far as to line up parallel passages in order to demonstrate their compatibility. But this attempt failed as completely as did Jacopo Mazzoni’s turn at the age-old game of reconciling Aristotle and Plato. After Lodovico Castelvetro published his Italian translation and commentary in 1570, Aristotle became almost as authoritative in poetics as he was in physics among the university philosophers. All the literary critic had now to do was to apply Aristotle’s principles to whatever piece of literature came along. Unfortunately, just what Aristotle said, or might have said, became the subject of a hot debate—particularly with regard to such current literary forms as the madrigal, which Aristotle, alas, had not heard of. And the Aristotelians took turns tearing up Ariosto and Tasso and then tearing up each other until they succeeded in imposing on Italian literature what Weinberg called the “disastrous purification” of the Gerusalemme liberata.

As Aristotle’s authority began to waver under the impact of the debates among the Aristotelians, it was challenged by the same Platonist who was later to offer a Platonic substitute for Aristotelian physics, Francesco Patrizi. The result was not the triumph of one ancient authority over the other.

60 Francesco Patrizi, Della Poetica (Florence, 1969–71); several of his philosophic and scientific treatises have also recently been edited by Danilo Aguzzi Barbagli and published by the Istituto Nazionale di Studi sul Rinascimento in Florence. Patrizi says, “[Aristotle’s] position, presented without any proof and without a clear definition of what imitation is, has always raised doubts in our mind” (2:80).
Rather, it was first the reduction of all the ancient authorities to the role of "guides," and then their rejection even in that role by those whom the critics claimed to be the chief beneficiaries of their speculative endeavors, the poets. Taking the advice Speroni had given as early as 1564, the Italian poets of the late sixteenth century reverted to the practice of imitation that had been dominant during the first age of humanism: If you want to write epic poetry, imitate Vergil, just as Vergil imitated Homer, and forget about the rules of the theorists. Eventually, indeed, the poets stopped bothering even to imitate; and the result was the "baroque" poetry of Giambattista Marino, some of which is dedicated to the celebration of Galileo's discoveries, and most of which is meant to be a practical demonstration of the superiority of Marino over Petrarch, Vergil, Bembo, and all the poets of the Renaissance and Antiquity put together.\footnote{On Marino, I follow Franco Croce, one of whose essays, "Baroque Poetry: New Tasks for the Criticism of Marino and of Marinism," is published in English in my Late Italian Renaissance, 377–400, where other titles from his considerable bibliography are cited. But current views on Marino differ considerably, as is evident in James V. Mirollo, "Mannerist and Baroque Lyric styles in Marino and the Marinisti" in the special issue entitled Seicento Revisited of Forum Italicum, 7 (1973): 318–37.}

The fourth, and perhaps the most important, contribution of humanism to the birth of science consists in what Vasoli has identified as the redefinition of the nature and function of dialectic. As it was defined by Leonardo Bruni, by Lorenzo Valla, and most notably by Giorgio of Trebizond, dialectic was based not on the texts of Aristotle or the practice of the late medieval universities, but on the texts of Cicero and Quintilian. It was elaborated not in response to the debating traditions of the universities but in response to the particular conditions of Italian urban society.\footnote{In general, Cesare Vasoli, La dialettica e la retorica dell'umanesimo: Invenzione e metodo nella cultura del XV e XVI secolo (Milan, 1968), and in particular, Eugenio Garin, "La 'retorica' di Leonardo Bruni," in Dal Rinascimento all'illuminismo (Pisa, 1970).} It was therefore united with rhetoric, in accordance with the humanist principle that knowledge is sterile unless it is communicated, that demonstration is useless unless it persuades. In the quattrocento, this principle obliged the humanists to express themselves either in the language of Cicero and Petrarch or in the language of Boccaccio and Alberti's On the Family, depending on whether their audience was Italian or Florentine. In the Cinquecento, it obliged them to write solely in the language that the Accademia Fiorentina, on the authority of Bembo, proclaimed to be the common language of all Italians.\footnote{Note Armando De Gaetano, "G. B. Gelli and the Rebellion against Latin," Studies in the Renaissance, 14 (1967): 131–38, and Mario Pozzi, "Il pensiero linguistico di Vincenzo Borghini, "Giornale storico della letteratura italiana, 148 (1971): 216–94, and 149 (1972): 207–68. See now De Gaetano's G. B. Gelli and the Florentine Academy (Florence, 1976).} That is why Galileo, whose friends in the Florentine Accademia della Crusca published the first edition of their Vocabolario on the eve of his return to Florence, wrote his most important works in Tuscan Italian rather than in the technical Latin of the universities. And that is why, at least after he emerged from the strictly university environment of Padua, he chose to cast his writings in the form not of treatises and commentaries, but of dialogues and personal letters.\footnote{As I pointed out in "The Florentine Background of Galileo's Work," in McMullin, ed., Galileo, Man of Science.}
those were the forms that had been sanctioned by the humanist tradition since
the time of Petrarch—not only because they had been used by the ancient
rhetoricians, but also because they were rhetorically effective. Realism and
the unity of space in painting permitted the viewer to associate directly with
the istoria depicted—and hence to be moved fully or persuaded by its message.
Dialogues and letters in philosophy invited the reader to participate actively
in the discussion of the question proposed—and hence to accept more readily
the arguments of the interlocutors.

The unity of dialectic and rhetoric also obliged the humanists to address
themselves to the widest possible audience, not just to specialists. As the
humanists' audience expanded from the notaries and rhetoricians of the time
of Salutati to the merchant-bankers of the time of Alberti, and as it expanded
finally to include the cobbler, carpenters, and druggists who attended the
lectures of the Accademia Fiorentina, so, gradually, even those subjects which
had previously been left to the specialists were at last made available to the
general reading public—a social category, by the way, for which the human-
ists deserve much of the credit. Breaking down the ivory towers in which
natural philosophy had been enclosed throughout the first century of human-
ism to some extent resulted from the new fashion among patricians of sending
their sons to be educated, or "finished," at the universities—which, after all,
they supervised and paid for. It also resulted from the establishment, first at
Ferrara and then at Padua, Bologna, Pisa, and Pavia, of chairs in literature
and languages. When students with a humanistic preparation began to
attend lectures, and when humanistic scholars began to teach at the univer-
sities, it was inevitable that they got to know the professors in the older
faculties. Eventually the humanists and philosophers who now associated as
colleagues came together in common institutions, of which the best known is
the Accademia degli Infiammati at Padua. In these institutions each member
expounded his particular subject of study to the others; and when the philoso-
phers spoke, they were forced, for the purposes of communication, to translate
the technical language in which they usually thought into the language of the
humanists, which everyone understood. Then the humanists who had at-
tended courses in philosophy began to report on what they learned to the
completely lay audiences in the new humanist institutions being founded in
all the major cities of Italy—the best known is the Accademia Fiorentina.

Thus humanism added still another discipline to the five or six which Paul
Oskar Kristeller says it had been restricted to before the 1540s. That is, to
history, poetry, ethics, et al., they added natural philosophy, or at least what
the university professors of their day said about the structure and substance of
the physical world. Consequently, such subjects, once reserved for the class-
rooms, were now discussed even in such purely literary works as Giovan
Battista Gelli's science-fiction fantasies. The humanist popularizers made few

---

65 See for example Charles Schmitt, "The Faculty of Arts at Pisa at the Time of Galileo," Pfyii, 14
contributions of their own, to be sure, and they were generally unprepared to evaluate critically the theses they reported, as Umberto Pirotti has shown in his study of Benedetto Varchi. But they succeeded nonetheless in arousing an interest in subjects that the Galileans were later to transform into sciences among the public at large—a public, insisted Alessandro Piccolomini, which included women as well as men. That was the public to which Galileo turned for support after 1610, a public composed not of university professors, but of ordinary citizens, like Michelangelo Buonarroti, Jacopo Nardi, Cosimo de’ Bardi—and, of course, Cosimo II de’ Medici and Cristina of Lorraine. For these citizens were by now familiar with the questions and terms that Galileo proposed to them; and it was they, the spiritual heirs not of Nicoletto Vernia and Paolo Veneto, but of Alberti and Guicciardini, who took on the task of defending, divulging, and further developing what they received from him.

To call Galileo a humanist may be something of an exaggeration. For by the time he reached his maturity, many of the subjects to which the humanists had long been dedicated, such as history, political philosophy, and theology, had either lost their relevance or been turned once again back to specialists. Moreover, Galileo’s disciples became scientists in a manner which would have been inconceivable to their humanist forebears. That is, they stuck to their researches; and whenever they felt moved to delve momentarily into other fields, as Francesco Redi did in poetry and lexicography, they took care to separate their pastimes from their professions. Yet without the background of humanism, Galileo’s accomplishment would be incomprehensible. Humanism made him independent of established authority. It provided him with his audience. And it gave him his modes of expression. Indeed, insofar as he used his own poetic efforts to undermine his opponents, insofar as he adopted as his guide through the border regions between science and theology none other than Petrarch’s favorite author, Augustine, and insofar as he discovered in the new science a way of escaping from the century-old conflict between philosophy and his own sincere Catholic faith, he can truly be called, if not the last of the humanists, at least a faithful heir of the humanist tradition.

66 Umberto Pirotti, Benedetto Varchi e la cultura del suo tempo (Florence, 1971).
67 Besides Vasoli, Florindo Cerreta, Alessandro Piccolomini, letterato e filosofo senese del Cinquecento (Siena, 1960); on which see Riccardo Scrivano, “Alessandro Piccolomini” in La rassegna della letteratura italiana, 68 (1964): 63-84.