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THE REVIVAL OF ANCIENT SCIENCE IN FLORENCE

Those who have been able to trace the influence of the special talents of the Tuscans in general, and of the Florentines in particular, on their artistic, literary and political accomplishments will have noticed that, first, the same individual and personal characteristics also mark the structure of the Scientific Revolution; and that, second, the source from which they spring is to be found in the same Hellenic artistic and scientific heritage brought to Italy from the Near and Far East by those roads which carried the conquests of the Greek genius.

Tradition has it that Thales of Miletus (600 B. C.) sailed to Egypt in his youth for reasons of trade and acquired the first notions of geometry and astronomy from that beautiful and advanced civilization. Returning to his native land with this treasure of ideas he established the foundations of a philosophical and scientific doctrine which immortalized his name and that of his successors (Mamercus, Anaximander, Anaximenes) with the school of physicism, called the Ionic school.

If we skip eighteen centuries we find a parallel to the Greek explorer in the Pisan merchant, Leonardo Fibonacci, who, because of his long commercial voyages to Greece, Syria and Egypt, acquired the nickname "bigollo", or "bighellone". The struggles between the Papacy and the Empire engaged by Pope Gregory VII (1013—1085), promoted communal freedom and lent a new splendor to Italian civilization. In particular, they enhanced the glory of the maritime cities, Amalfi, Genoa, Pisa, which precended that of the Florentine Renaissance and established commercial houses in the East. Another link was established between the Hellenic civilization, handed down to us in the writings of the Arab world, and that of Europe. The crusades nourished this new source. One would say that scientific progress, dammed up by a dyke, stagnated without benefiting the arid regions: once the dam was broken the beneficial flow ran in many streams to quench the

thirsty land, and Leonardo Fibonacci was one of these streams. Not only Italy but also all Europe could quench its thirst in this new fountain.

Fibonacci (1202—1228) wrote a book on the *Abbacus*, and a *Pratica Geometrica* (1225); he dedicated the *Liber Quadraturarum* to Frederick II Hohenstaufen. He was the first popularizer of Indian and Arab works; for example, the theorem for calculating the area of a triangle given the three sides must be attributed to the Indians. From the latter Leonardo deduced a system of decimal notation, introducing the number zero which takes its value from its position; this represents a great step forward in written notation. In algebra he solved second-degree equations and in number theory shown how to extract the cube root of a rational number.

The thirteenth century is without doubt a century of great awakening in every form of intellectual and artistic endeavour; and one can say that the glory is established by that manuscript of human doctrine — the *Divine Comedy*. If Dante (1265—1321) had been nothing but a poet, the historian of science could but admire him from afar. He was, however, the most universal man, the most profound scientist, and the most acute observer of his time. In the *Divine Comedy*, which can also be considered an artistic digest, an encyclopedia, one can find observations that might be vainly searched for in other works (cf. Guglielmo Libri, *Histoire des sciences mathématiques en Italie*). His incisive remarks on meteorological phenomena are very famous, e. g.:

Ben sai come nell'aere si raccoglie
quell'umido vapor che in acqua riede,
tosto che sale dove'l freddo il coglie. [1]
(*Purg.* v. 109—111)

Although the discovery of the formation of vapor by adiabatic expansion cannot, according to modern theories, be attributed to Dante, the tercet is certainly the live poetic expression of the real nature of the phenomenon. The scientific doctrines of the Stagirite, of which Dante can be called a follower, shaped the Florentine mind with their empiric realism. Three centuries later another Florentine, Galileo (who, with his aversion to the peripatetics dominant in teaching, was often to assume an antagonistic attitude to Aristotle), possessed the very same spirit of observation, realistic mentality and admiration for natural phenomena.

In the *Divine Comedy*, as well as in the *Convivium*, Dante shows a profound and exact knowledge of the astronomy of his times. Indeed

[1] "You know well how aequeous vapor gathers in the air and turns again to water when it rises where the cold draws it."

we can say that, with the exception of an error made, perhaps, through no fault of his own, when he alludes to Venus;

> *Lo bel pianeta che d'amar conforta*
> *faceva tutto rider l'oriente*
> *velando, Pesci, ch'erano in sua scorta.*,[2]
> (*Purg.* i. 19—21)

the entire Ptolemaic astronomical and cosmogonical fabric fit into the moral and theological context of the vision of life in the other world. It can be asserted that, considering the nature of the poet, in his search for precision and in the blending of an ethical and aesthetic harmony with cosmogonical lens, Dante had made observations as a philosopher, singling out and penetrating topics that were precisely defined only by the modern and advanced scientists. He described the sleep of plants (*Inf.* iii. 127), recognized the cryptographic plants (*Purg.* xxviii. 115—118), and the action of sunshine on the maturation of fruit (*Purg.* xxv. 77—78); he observed the flight of birds and the twinkling of stars; he performed and recommended experiment and used it in comparisons:

> *Dilettossi di musica e di suoni*
> *e di sua mano egregiamente disegnava.*[3]
> (*Purg.* xv. 16)

After Fibonacci, who must be considered the greatest medieval geometrician, comes the Dominican Leonardo da Pistoia (1208). Perhaps the German, Giordano the Nemovarius, should also be listed among the Dominicans, as he was the most accomplished writer on mathematics and statistics. He deserves particular emphasis because, besides Biagio Pelacani, he was the main source of studies on mechanics to which Leonardo da Vinci later turned, whereas for studies on optics and perspective he used the work of the Arab Alhazen (eleventh century).

The use of spectacles dates back to the end of the thirteenth and the beginning of the fourteenth centuries. The Pisan, Alessandro Spina contributed to its popularization in Tuscany. Medicine in Florence found a highly esteemed professional in the Hippocratic tradition in Taddeo degli Alderotti (1223—1270), mentioned by Dante (*Par.* xii. 83). He dedicated to Corso Donati his *Della conservazione della salute*, one of the first texts written in the vernacular. It seems that he made quite a profit in practicing his profession, such that he had a reputation of stinginess. He did in fact die rich, but left much to charity.

In those first centuries of the scientific renascence, Italian medicine became famous, following the Salernitan School and the contributions

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[2] "The beautiful planet that induces love made all the East glow, eclipsing Pisces, who were in her escort."

[3] "He enjoyed music and songs and drew well with his own hand."

of Ruggero di Salerno, Rolando da Parma (1240), Guglielmo da Saliceto, and Lanfranco da Milano (d. 1306). The study of chemistry, anatomy and botany was added to that of medicine.

An important place in astronomy belongs to the Genoese explorer Andalò di Negro (1260—1340), who held the chair in Florence, succeeding Cecco d'Ascoli. About 1330 he was the teacher of Boccaccio, who boasted of long trips and an astronomical culture. It seems relevant to mention a manuscript of Andalò, not an autograph but in a much more recent hand (early sixteenth century), consisting of a copy of the *Teorica dei pianeti secondo Andalò*. It is preceded by a very detailed desciption of the famous astronomical clock, or better, planetarium of Lorenzo della Volpaia, mentioned briefly by Poliziano in a letter to the Sienese Francesco della Casa. The manuscript appears to be written by one of Lorenzo's sons.

The combination of the two writings so far apart in time, the *Teorica* of Andalò and the clock of della Volpaia, would confirm the conjecture that, at the time of the former, a private study of astronomy had already begun in Florence, leading to the rise of an artisan class, capable and learned in the construction of mathematical instruments. The della Volpaia family (Lorenzo, Benvenuto, Eufrosio, Cammillo, Girolamo) was the first and leading exponent of this class. With their accurate workmanship they created instruments found today in many European museums. In ours there are well preserved armillaries, quadrants, solar and nocturnal clocks.

The most illustrious mathematician after Fibonacci was the Florentine, Paolo Dogamari (1281—1365) buried in S. Trinità where his tomb is irrecoverable today. The *Regoluzze* is his most important work. He also wrote a treatise on arithmetic and algebra, one on astrology and the *Operatio Cilindri*. This work deals with a cylindrical instrument which could be used to find the age of the moon, the hour and angular height of the sun and moon or the height of a terrestrial object. He left the *Tabulae planetarum ad annum 1366* and a treatise on the *Quantità chontinue*.

If the Florentines were preceded by the maritime republics in the race to explore and acquire geographical information, they, too, soon turned their attention to more remote regions to ensure goods for their industries which had gradually gained renown. Crusaders, missionaries, merchants or persons eager for knowledge went abroad, particularly to the Far East, from where came numerous articles of trade known by the name "spices". Thus we find Francesco Balducci Pegolotti, in the service of the Bardi Bank; he travelled in the Levant from 1315 to 1340 and, according to some sources, went as far as Peking. There follow Giovanni di Marignolli (1339—1353), Angiolino di Corbizzi (1341), Niccolò

da Poggibonsi (1345), Leonardo Frescobaldi (1384—1385), Simone Sigoli (1384—1385), Giorgio Gucci (1384—1385) Andrea Rinuccini (1384—1385), Bartolomeo Fiorentino (1400—1424), Cristoforo Buondelmonti (1415—1440), Benedetto Dei (1462—1477), who reached Timbuktu in the centre of Africa; Filippo Buonaccorsi (1470), Amerigo Vespucci (1480—1503). With this last we have reached Columbus' era and will take this opportunity to mention first a scientist in whose geographical and astronomical knowledge we find information that must have been drawn from reports sent by the Florentine explorers mentioned above.

The Studio Fiorentino founded by decree in 1321 gave rise to another decree in 1364 with which the Emperor Charles IV declared it the imperial university. In 1368 there were seventeen professors and the curriculum included: theology, law, medicine, astrology, logic, and philosophy. There ensued a period of decadence but, after 1417, another period of growth. The mathematical sciences were paid less. Thus, Giovanni dell' Abbaco received twenty florins a year, while the physician Girolamo di Giovanni da San Miniato received sixty, and the famous doctor, Ugo Benzi, six hundred.

In the fifteenth century the mathematical sciences, astronomy, geography, and cartography were enlightened by a man, who, perhaps because of his modesty, meek character and upright habits (in contrast to the corruption of the times) did not win recognition during his lifetime; nor could he reach a position to which his intrinsic merits entitled him. Only much later his contributions were acknowledged thanks to the work of modern historians, particularly to the accurate researches of Gustavo Uzielli. This scientist, who worked in the period just preceding that of Columbus and Vespucci, was Paolo dal Pozzo Toscanelli, born in Florence in 1397; he died 10 May 1487.

First he took courses at the Studio Fiorentino where he studied mathematics; then he passed to the Studio di Padova, at that time of European renown, where he made friends with Nicholas of Cusa (1405—1464) and many learned men. He studied mathematics with Prosdocimo Beldomandi, the famous Padovan scientist. He returned to Florence in 1424 and made friends with Leon Battista Alberti and Filippo Brunelleschi, who was his elder by 20 years.

It is not hazardous to guess that Toscanelli's particular knowledge of the exact sciences influenced the work of the famous architect, whose artistic genius was coupled with a special affinity for geometry. At that time, Brunelleschi (1377—1446) was engaged in building the dome to decorate the cathedral, which serves as a symbolic monument of the apex reached by Florentine architecture.

One cannot say precisely whether and how Toscanelli's indirect teaching was useful in designing the vault of the dome, because the

glory of this construction belongs entirely to Brunelleschi, and rightly so. Nevertheless, as Ximenes observes: "it is very certain that the curve of our dome is such that it comes very near to the catenary curve, which is very suitable for dome constructions." And Poleni adds: "so, with the strength of his architectonic genius and perhaps using many observations taken from experience, Brunelleschi introduced the catenary curve to the gothic arch which two or three centuries after his death was to be found of maximum resistance." And the circular arch, the approximate maximum of the catenary, selected by Brunelleschi is a shining example of the beneficial interaction of art and science, as was the curve of Ammannati in the destroyed Ponte S. Trinità.

Howsoever the relations between Brunelleschi and Toscanelli developed, the result was that Toscanelli became a member of the Commission appointed by the *opera del Duomo* and intervened often with good advice.

Meanwhile Toscanelli, using the reports of travellers returning from the Far East, became more and more involved in geographical studies. He was also interested in the description of those regions from where spices came. He envisioned the earth as Benheim did, availing himself of references sent to him by the explorer, Bartolomeo Fiorentino.

These studies of cartographic documents brought him the reputation of the foremost authority on geography in all Europe. Fifteenth century cartography rests substantially on Ptolemaic geography (2nd cent. B.C.). Among the publications of that time we can mention those of Francesco Berlinghieri (d. 1482) and fra Giocondo (1435—1515). But a grave defect of this science was the plotting of geographical co-ordinates. For latitudes, which involves measuring the heights of the pole on the horizon, astrolabes and quadrants were quite satisfactory: but for longitudes, which, as it is known, roughly followed the days of navigation, they encountered errors which grew excessively with distances computed according to the parallels. Above all, the Far Eastern regions were extraordinarily long on maps, because of the difficulties in plotting the longitudes with sufficient approximation, so that Toscanelli gave Kinsai (Hangchow) the east longitude 223° instead of 121° 25', thus confusing the East China Sea with the waters of the Atlantic in relation to the Gulf of Mexico; in other words, he eliminated almost all the Pacific Ocean from navigation.

A lucky mistake! The illusion of opening a new and shorter route to the countries of the Levant by sailing westward encouraged the completion of a crossing which has become legendary. Columbus, although he never reached the territory he expected, but discovered others instead, was persuaded as long as he lived that he had indeed come upon the lands which jut out into waters of the China Sea.

We shall not expatiate upon Columbus' famous accomplishments as they have no direct bearing on Florentine history. Toscanelli, however, almost in the guise of a 'godfather' was indirectly associated with this daring undertaking, for, with geography he was able to show the possible success of an adventure which would otherwise have meant the risk of a tragic failure.

As an astronomer, Toscanelli made observations of the comets of 1433, 1449—50, 1456 (Halley), January, June, July and August 1457, and 1472. Celoria (*Raccolta Colombiana*, vol. V, part 1) gives this judgement; "It would be unjust to deny a degree of precision to Toscanelli's observations, which is noteworthy for the time in which these observations were made. Observations of comets prior to those of Toscanelli do not exist; and for their number, for the form in which they are described and for their intrinsic precision, his are comparable to those discussed here."

Toscanelli's name was brought to light for the first time by Ignazio Danti, who recalled his great talent, particularly in astronomy, citing the large gnomon constructed in the dome of Santa Maria del Fiore. The famous astronomer Lalande, who saw it in 1765, called it the greatest existing astronomical monument; it is still functioning toward the summer solstice.

With the name of the great Genoese explorer one must associate that of the Florentine, Amerigo Vespucci, who was perhaps the first to solve the problem of the existence of a new world quite apart from that of the East Indies.

Vespucci, as an explorer of Columbus' period, identified most of the coasts of the New World. More intelligent and cultured than Columbus, he reaped better fruits, but he was not very ambitious and did not enjoy the glory that Columbus did in his lifetime. He did not even attain the honors, riches, high offices, or the misfortunes that the other did. Furthermore, the scarcity of documents, in addition to errors and contradictions found in those which have come down to our days, makes it really difficult to examine his work thoroughly and critically. The prejudiced hostility of many historians has almost hidden his merits, showing him as a usurper of Columbus' glory (*e.g.* Magnani).

But if one must credit the daring Columbus with having found a new route to new discoveries, the second place in the Columbian period undoubtedly goes to the Florentine, who because of many intrinsic merits, excelled Columbus. Vespucci was more modest and less ostentatious than Columbus and did not boast of his worth to kings and princes to obtain great riches as the reward of conquest. If he did get an office of the first order it was always a work of administrative or technical nature due to him for his skill. Columbus was a great

admiral and viceroy of the conquered territories and received 10% of all the treasures unearthed in the new lands. Unfortunately, Columbus had also to experience the evil ways of the jealous and the ungrateful, who profited by his great mistakes, and after having tasted the greatest heights of glory he lived his last years almost forgotten. One scarcely knows where he died but history has erected a lasting monument to him and his fame shall endure for centuries.

Now we must mention that the question of Vespucci traces its origins to Saint Diè, a little village of the Vosges where, at that time, there resided a famous gymnasium and cartographers who, while very esteemed, contributed to the diffusion of errors and confusion. The peculiarity of the case is that this little village, helped perhaps by the correspondence which Vespucci as cosmographer had to keep with the gymnasium, enjoys the honor of having baptized America through Martino Waldseemüller (Ilacomilus), author of *Cosmographiae Introductio.* In this work, which appeared in 1507 and immediately went through many editions (now very rare), the writer, after considering general principles, gives a description of Vespucci's four voyages, probably based on a report given by the Florentine himself. From these descriptions a map of the world was prepared, complementing that of Ptolemy and the ancient geographers and adding to the three known regions a fourth, which until then had been lacking.

After Vespucci the most famous 16th century Florentine explorers were Giovanni da Empoli (b. 1483, d. 1518) well known as an ardent sailor, soldier and merchant who travelled far in India and Brazil; Andrea Corsali (1515—26), famous for the circumnavigation of Africa and an erudite observer of the natural sciences, geography and astronomy; Giovanni de Verrazzano (1523—7) an explorer of the northern regions of America on behalf of King François I of France; and Filippo Sassetti (1540—1588), who explored India and Brazil and wrote, in addition to a biography of Ferrucci, *The Commercial Treaty between Tuscany and the Levant (Il ragionamento del Commercio fra i Toscani e i Levantini).*

Toward the end of the fifteenth and during the sixteenth centuries, Italian science was enriched by the names of Fracastoro, Maurolico, Comandino, Benedetti, Francesco Galigai (who in 1521 dedicated the *Summa Aritmetica* to Cardinal Giulio dei Medici), Sfortunati, the Sienese involved in the problem between Tartaglia and Cardano; Caetano, the Sienese of the *Pratica delle matematiche;* Scipione Ferro, Antonio Fiore, Ferrari, Raffaele Bonibelli. All these men, only in part Tuscan, as precursors of Galileo and his disciples, effectively contributed to the development of mathematics and the principles of dynamic mechanics;

Tartaglia and Benedetti are to be given the first place among the scientists of the 16th century.

We must not overlook the name of the Florentine historian Benedetto Varchi (1502—1565), a man of great learning and a translator of Euclid. Writing against alchemists in his *Questione dell' Alchimia* (1544) he proves to be an excellent observer, and in attacking the authority of Aristotle, he can claim to be among the precursors of the Galilean philosophy: "Although it is always the habit of modern philosophers to believe and never prove all that they find in good writers, above all in Aristotle, this does not mean that it would not be both better and more interesting to do otherwise, and to turn to experience once in a while in certain cases, for example, in the movement of heavy objects, where Aristotle and all the other philosophers, not having once questioned it, have believed and affirmed that the heavier an object the faster it falls—this has not proved to be true. And if I were not afraid of straying too far from my proposed subject, I would digress further to prove this notion which I share with others, particularly with the Reverend Padre Francesco Beato, no less a learned philosopher than a good theologian, metaphysician of Pisa; and Luca Ghini, who, besides being a physician and very remarkable herbalist, appeared to know all the minerals, both theoretically and practically, when I heard him lecture publicly at the Studio of Bologna."

Ghini taught Cesalpino, Aldovrandi, Mattioli and Anguillara; it is believed that in 1544 he founded the first botanical garden to be used for teaching in Pisa.

Since minerology has been mentioned, one must recall a precursor of Stenone (1638—1686) in the person of the Sienese Vannoccio Biringuccio (1480—1539), who, a century and a half earlier, foresaw the law (attributed to Stenone) of the constancy of angles, fundamental to crystal morphology. Stenone, of Danish origin, settled in Florence where he lived a long time as physician to the Grand Duke Ferdinand II. Many of his manuscripts are now found in the Biblioteca Nazionale Centrale of Florence and in the Laurenziana library; his body lies in the basilica of San Lorenzo.

For the history of the calendar one cannot overlook Ignazio Danti (1537—1586), a Dominican of an illustrious Perugian family, who lived and worked mostly in Florence, where he taught mathematics and left outstanding works. Cosimo I entrusted to him the task of joining the Adriatic and the Tyrrhenian. With his large maps he became the cosmographer of the court. On the façade of Santa Maria Novella, one can still admire his equinoctial armillary and a time quadrant; nothing is known of a solstitial gnomon which he had planned to build in the church. We have also a large terrestrial globe of his but in terrible

condition. In our museum there is an instrument of the Primum Mobile. The following of his publications should be mentioned: *Le scienze matematiche ridotte a tavole, Il Trattato dell' Astrolabio* and an edition of Vignola on perspective with abundant notes.

With Danti and the astronomer Antonio Magini we reach the end of the 16th century and the beginning of the Galilean era, but before that we must go back one step.

Vasari in his life of Piero della Francesca (1410—1492) begins thus: "Piero della Francesca of Borgo a San Sepolcro, while he was considered an unusual master of the difficulties of regular bodies, arithmetic and geometry, could not publish his many writings and other valuable works once blindness had overtaken him in his old age, at the end of his life; these works are near preserval in his home at Borgo. The man who should have done his utmost to enhance Piero's reputation and fame, since Piero taught him all he knew, was cruel and malicious. He tried to erase the name of Piero, his teacher, and steal for himself that honor which belonged to Piero alone by publishing under his own name, i.e. Fra Luca del Borgo (Luca Pacioli) (1440—1510), all the efforts of that fine old man, who in addition to the above-mentioned sciences, was an excellent painter."

If a sense of justice and respect for the property of others, its material goods or the fruits of talent, did not arouse such disgust for this encroachment, we could at least be grateful to Luca Pacioli's plagiarism which did bring to light the work of his compatriot. The verification of Pacioli's appropriation has been recently proved by Mancini for what regards the comparison of Piero's *De Corporibus Regolaribus* and Pacioli's *Divina proportione*. Pacioli, however, morally censurable for plagiarism, was not just a vulgar thief; he does stand on his own merits of his own contribution to the exact sciences. He lived in Florence during some of his last years. His major works are the *Summa* de *Arithmetica, geometria proportioni et proportionalità* and the *Divina proportione* where the drawings of the regular bodies are said to have been etched by Leonardo da Vinci.

The marriage of art and science, in one person, for professional reasons, is not infrequent; Alberti, Dürer, Cigoli, Vignola and many others demonstrate the usefulness, nay the necessity for painters and architects to have a particular affinity for that part of geometric optics called perspective.

The early architects of gothic churches, faced with the necessity of intertwining many different mouldings, without any idea of advanced geometry, had already been forced to solve empirically the very complex and difficult problem of constructing the curved intersection of cones, cylinders and other more complicated solids. A particular

aptitude, trained to perceive with the mind's eye the simultaneous effect of two interpenetrating solid bodies, is found in these precursors of modern geometry. Ufortunately, the Middle Ages and the Renaissance cared little or nothing for the diffusion of the methods and empirical systems of all applied mechanics and handicraft. Hence, with rare exceptions, little is known of the links between theory and practice, between scientist and artisan, each one understood in its broadest meaning. One can say that Leonardo da Vinci's manuscripts are the most noteworthy, not only for what they contribute to the admiration of the fecundity of his genius, but also for what they tell us about the conditions of applied mechanics in his day. Only much later, after the spread of the printing press, did one think to publish books which might be regarded precursors of our rich technology.

At that time Tuscany ssemed destined to show the whole world the genius of its people. Leonardo da Vinci, the most dazzling star, dimmed only by the glory of the Galilean period, is described thus by Vasari: "Leonardo (1457—1519), son of Piero da Vinci, was truly wonderful and divine. He would have made great progress in learning and literature, had he not been so veratile and fickle. Hence he would set about to learn many things, but once begun he would abandon them... Here, for example, in the arithmetic, in the few months that he attended, he had learned so much that he very often confused the teacher by continually bringing up doubts and questions. He studied a certain amount of music, but immediately decided to learn to play the lute as one who naturally had a very lofty spirit and was very graceful; besides that he sang wonderfully, improvising. That Leonardo was endowed by Nature with a genius vast and profound but quite frankly inconclusive and chaotic, has been acknowledged by the most impassioned students of his works." "Countless treatises," writes Favaro, „of which he speaks at times as if they were completed works were perhaps never drafted, and put in order... So it often happens that he quotes the ordinal number of a proposition of a work which he had thought of but had never written up in the form of an index."

Given the tumultuous disorder in da Vinci's manuscripts and the fact that neither during his lifetime nor afterwards could they be studied by contemporaries, it is logical to deduce that Leonardo's work had no effect whatsoever on the scientific renaissance which precedes the Galilean period. That his manuscripts, drawings, and instruments, which had become the property of his student, Francesco Melzi, were scattered and underwent many vicissitudes, is well known to the students of da Vinci's work. Only Cellini speaks of Vinci's treatise on perspective; in 1651 the *Trattato della Pittura* was published in Paris, in a very arbitrary arrangement. Not until 1797 with Venturi — *Essai*

sur les ouvrages de Leonard de Vinci — and with the broader views of Amoretti and Libri, did the exegesis of Leonardian manuscripts begin.

Only just recently, however, could these manuscripts be put within the reach of Italian and foreign scholars; and once they were critically examined, he could be given the place which was assigned to him with respect to his predecessors.

Undoubtedly his writings give expressive and picturesque form to difficult and profound questions brought up by his direct investigation of natural phenomena. Personal experience and the extensive culture acquired by the examination of works known to Hellenic civilization (which he had certainly been able to study in the collections offered by the cities through which his restlessness had driven him to roam). constitute the rich material of notes and personal considerations in every branch of science: mechanics, mathematics, hydraulics, geology, comparative anatomy, physiology, botany, astronomy, optics are all subjects which follow one another almost desultorily without organic links. In that rich collection all the observations on the flight of birds stand out because of the draft's organicity; here the content has an intrinsic value apart from any possible bold application; perhaps one can find a glint of prophecy with regard to the application of an actual glider. A less known rival of Leonardo was Giovanni Battista Danti of the famous Perugian family.

We come now to the apex of the scientific renaissance, concentrated in the Galilean school. Very many other sources contributed to it, but Leonardo's influence, for the above-mentioned reasons, was almost nil; his efforts rested in the shade. Even in a comparison of Galileo's production with that of da Vinci, the student cannot but notice the superiority of the first both in the intrinsic value of his discoveries and astronomical and mechanical observations and in the organic drafting and direct effects which it could have on his successors. One cannot deny or forget Galileo's contribution to the history of science; he constitutes a link without which the chain breaks, and Newton does not connect with Copernicus. Copernicus, Kepler, Galileo and Newton are well-defined but related figures. Not Leonardo. He is a figure unto himself; in science his personality has no productive value and he is connected with neither his contemporaries nor his immediate successors. His is a science of profound considerations and extensive learning.

One must then recognize that with respect to Galileo's more constructive work, Leonardo's was sterile and inconclusive. Galileo, having a mind at once practical and speculative, talks like a scientist and has the order and clarity of a scientist in expository writing. Instead Leonardo seems preoccupied with just brief strokes, notes and vivid expressions, the stretch of numerous observations of things seen with

the eye of an artist who cared little for rational and methodical co-ordination.

Since the days of Fibonacci down to those of Galileo all the regions of Italy, but particularly Tuscany, enriched their scientific heritage with their own efforts, and with some foreign ideas. This was mainly due to the progress of classical studies which diffused Greek and Arab texts, also in the fields of mathematics and astronomy by means of learned commentaries. It can be affirmed that almost all European culture up to the Galilean period was the fruit of Greek civilization; and mathematics was studied with the classical method of Euclid, Archimedes, Apollonius, *etc.*

It is an almost abrupt transition from the treatment of scientific problems according to the Hellenic school, and Aristotelian physics in particular, to the treatment of the same problems with post-Galilean methods; the jump from Ptolemaic astronomy to that of Kepler and Newton is almost revolutionary.

Undoubtedly this transition came about as a result of the impetus given to civilization by the geographical discoveries of the Columbian era, just as the earlier thirteenth century Renaissance can be tied to the explorers of the Far East.

These voyages furnished new and unforeseen material of unquestionable value for the natural sciences, zoology, botany, mineralogy, geology. Observations and measurements of the size and shape of the earth, which gradually became more and more precise (from Eratosthenes to the present) contributed directly to the progress of the mathematics of astronomy and geography. This problem of the shape of the earth led to many voyages in the distant parts of the globe; expeditions to Peru and Lapland undertaken by French scientists of the eighteenth century were memorable.

The meteorology of the earth, necessary in order to learn the fertility and habitability of the regions in the Old and New Worlds, made noticeable progress, nay a good beginning with the methodical measurements of barometric pressure, temperature, wind and hygrometric conditions which were begun with new instruments by the Grand Duke Ferdinand II de Medici. He deserves to be called the founder of meteorology.

All the prodigious activity of the Academicians of the Cimento was awakened and encouraged by the spirit of the Master (Galileo), who had brought about a rebirth of the experimental method.

History often abuses the term of patron by applying it to princes who by pure coincidence happened to live in periods of great intellectual activity. But Ferdinand II and his brother Leopold were real patrons who contributed to progress with their resources of great wealth and

co-operated directly with clever experiments and inventions. The Prince's personality was that of his people, which had imbibed a distinctly ingenious but often discorderly and tumultuous individualism like that seen in the social and political manifestations.

I began with a parallel between the origins of Greek science and that of Tuscany. I would like to conclude with another parallel. The Golden Age of Greek science was born and led a glorious life on the banks of the majestic Nile; and from Egyptian Alexandria spread as far as Sicily. One cannot deny that its impetus and diffusion was tied up to the enlightened patriotism of the Lagidian dynasty, particularly to its founder, Ptolemy Soterus, who established the famous library modelled on that of Aristotle and died shortly thereafter. With the Museum, organized to provide adequate means for speculation in natural philosophy and astronomical observations, the hospitality of the Ptolemies assured the civilized world of a long period of conquest in the mathematical and astronomical sciences.

All of Hellenism, from the banks of the Nile to the shores of Magna Grecia, shines with the names of Hipparchus, Aristarchus, Eratosthenes, Euclid, Archimedes, Apollonius, Ptolemy, etc. There followed a Silver Age and decadence; the Hellenic world gave to other peoples their rich heritage accumulated for centuries.

Twenty centuries later, on the banks of the river that rises in Falterona, Ferdinand II and his brother, Prince Leopold of the Medici family, as has been said, founded the Academy of the Cimento as if to reflect the light of the Alexandrian Museum. From here came the disciples of the Galilean school; and experimental sciences in Tuscany reached their apex of their trajectory.

After this brief period, which passed like a flaming meteor, there followed only stars of second and third grade in the Florentine sky. Only later did experimental sciences revive for a moment under the patronage of the Lorraine Grand Dukes.

The intellectual supremacy of Tuscany, evoked by us with the names of Fibonacci, Dante, Toscanelli, Vespucci, Leonardo and Galileo is truly a great glory of our past.