Point of View

The right of each person to express his individuality is perhaps the most jealously guarded prerogative in modern Western society. We exercise this right in various ways: in the vote, in freedom of expression and movement, and in more personal forms such as our career, home and appearance. In each of these manifestations we express our difference one from the other, our uniqueness. Concern for privacy, and the need to ensure protection for what information may exist at large about us, is a major determinant in the way we live. We maintain the correct personal distance from each other, we regard physical assault as a major crime. We allow the state to have many rights over us, but never to invade or detract from our own rights as individuals.

Most of us regard these rights as primarily political, sprung from the great democratic reforms of the eighteenth century. But those reforms might not have been possible without an intellectual revolution in thinking which occurred three hundred years earlier, in northern Italy. It was a revolution based on two events: the greatest holocaust the West has ever known, and a new way of painting.

In the summer of 1347 a merchant ship returning from the Black Sea entered the Sicilian port of Messina bringing with it the horrifying disease that came to be known as the Black Death. It struck rapidly. Within twenty-four hours of infection and the appearance of the first small black pustule, came an agonising death. The effect of the Black Death was appalling. In less than twenty years half the population of Europe had been killed, the countryside was devastated, and a period of optimism and growing economic welfare had been brought to a sudden and catastrophic end.

As the plague struck indiscriminately at rich and poor, those like the poet Boccaccio who could afford to do so fled the stink and terror of the cities for isolated retreats. The packed and insanitary towns suffered most. Some lost as many as three-quarters of their inhabitants. As the disease spread, there were not enough survivors remaining to bury the dead in the mass graves opened for the purpose outside the town walls.

Two views of the same city, Florence: above, fourteenth-century, below, sixteenth-century. They reveal two different attitudes to the world, coming as they did before and after the rediscovery of a method of painting that revolutionised mankind's view of the entire universe.
In the countryside too the effect was immediately evident. Without farm-workers to husband it the land went to waste. Livestock died in thousands. Villages were abandoned as wild dogs and bandits scavenged and looted the ruins. In Germany up to 60 per cent of the land went uncultivated. In Castile conditions in the countryside became so bad that it was dangerous to venture outside the towns. As the wayside inns closed, travellers were obliged to camp in the open like gypsies, catching and cooking their own food.

This was no ordinary widespread epidemic. To those at the time it seemed like the end of the world. With the entire economy dependent on agriculture for survival, and a population already dangerously close to the limit in terms of available food, the havoc on the land killed thousands more through starvation. Year after year the plague ravaged the Continent in a dance of death that brought a new image to the art of the time, a prancing, grinning skeleton, dragging its screaming victims to the grave. There was no escape.

It was to be a hundred years before the memory of those two decades passed, and nearly three centuries before the population reached pre-plague levels again. Those like Petrarch, the Italian poet, who survived felt that posterity would never believe it had happened.

After it was over, towards the end of the fourteenth century there was a new air abroad, a feeling of reckless joy at being alive. The survivors were rich, having inherited what the dead had left, so they went on a gigantic spending spree in an effort to wipe out the memory of those horrific years.

The citizens of Tournai, France, in 1349 burying their dead during the height of the Black Death. In depopulated Europe 'there was a vast and dreadful silence'.
But it was the change in the status of labour that had the greatest effect. The Black Death had killed half the workforce, and those that remained were desperately needed if enough food and raw materials were to be produced to help Europe recover. Their entire condition of life was altered. No longer helpless bonded serfs, the farm-workers became a commodity that could command any price for its efforts. All over the Continent the workers flexed their new-found industrial muscle, in displays of political insurrection that would have been unthinkable a generation before. With the general breakdown of authority came heresies. In England the Lollards, who preached political egalitarianism, were burned at the stake. In Czechoslovakia the radical reformer Jan Hus and his followers sparked civil war that was to end in devastation and a stream of refugees to the West, giving modern Europe a word for the anarchic and the unconventional: Bohemian. Everywhere it seemed that order had deserted society. In Scotland at the battle of Flodden, common men using longbows felled mounted aristocrats from their saddles with impunity.

Of all the countries ravaged by the Black Death, Italy made the fastest recovery – whether for climatic and agricultural reasons, or through early sanitary precautions, such as the introduction of health certificates for travellers, it is hard to say. The coalescence of rural power in the hands of a few major surviving landowners brought the country dwellers thronging to the cities. Around the northern Italian towns, whose citizens were spending their Black Death inheritance on fine new buildings of marble and stone, rose shanty towns filled with discontented urban poor.

In an attempt to stem the tide of revolution and hold down the trouble (such as the savage riots and disturbances in Burgundy, the Continent’s richest state), the Franciscan friars preached a new, individual form of salvation. In the Predicant churches, built wide and aisleless so that the congregation had a better view of the pulpit, there was little of the shadowed mystery of Gothic
This detail of a fourteenth-century fresco in the Spanish Chapel, Florence, shows the theological unconcern for realism. Saints are bigger than the good people of their flock (bottom), who are, in turn, bigger than sinful dancers (top).

architecture. The northern style had never really taken root in Italy; and without the influence of conservative theological centres such as existed in France, but rather a university tradition already strong in the mathematical and medical fields, Italian intellectual life was more open, more enquiring in nature than that of her neighbours to the north.

Enquiry, however, remained academic in nature, as it had been for over two centuries. The view of the times was still medieval. The universe was Aristotelian, with the earth at the centre, surrounded by the concentric crystal spheres each carrying the sun, the moon or the planets, and the outermost carrying the fixed stars.

Aristotelian teaching held that at Creation the Prime Mover, God, had set the heavens in perfect and eternal circular movement. There was no such thing as empty space, since even the apparent emptiness was filled by God’s presence. Everything existed only to glorify God. Paintings told stories from the Bible, and theological considerations limited the depiction of the protagonists to whatever size demanded by their liturgical importance in the story. With the prevailing medieval lack of interest in earthly things, no attempt was made to illustrate the world which surrounded the figures in the paintings. Gold paint was used to fill the spaces between the figures, to indicate God’s ubiquitous involvement.
Art also reflected the symbolism of the universe. Nothing was what it appeared. The universe was organic, living, and each part of it had moral worth: it was better to be high than low, constant than changing, at rest than moving. The hierarchy of relative value placed everything in nature. A noble was better than an ordinary man, below whom was woman, then came animals, then plants, then stones. This great ‘chain of being’ was subdivided into separate categories, each with their own hierarchy. Thus the king of beasts was the lion, the ruler of birds the eagle.

Magic was popular. Witches were consulted for medical treatment by the population at large. Alchemists sought the philosopher’s stone, the mysterious catalyst that would turn all to gold. Talismans, exorcism, tricks, symbols, cabalistic incantations were in widespread use. To the modern eye the world would have seemed filled with stage effects. But the people of the time believed in them. Demons, nymphs and fairies were real; they waited for children in the darkness at night.

Everything was made of the four elements: earth, water, air, fire. The four seasons corresponded to this fourfold division of the universe, as did everything in existence: four winds, four directions, the four ages of man. There was a relationship among all things, between the macrocosm in the sky and the microcosm on earth. For those who believed in this relationship, a building could be seen as a body, God was represented as the head of a large corporation, and men were capable, like laurel trees, of repelling lightning.

These relationships also ruled numbers, which themselves had magical properties. God had created the world in six days because 6 is the product of the adding, or multiplying together, of 1, 2 and 3. The number 7 was magic because of the seven heavenly crystal spheres, and because it was formed from 3 (the Trinity) and 4 (the elements). Its multiplicands (3, 4) also produced 12 (the Apostles).
This familiarity with numbers also had a practical value. At the time there were no standard measures. When commercial goods arrived at a market, the units of measure in which they had been described at their point of origin might well have no meaning to the potential buyer. So people were experienced in estimating size. In schools pupils were taught to gauge scales and sizes. Stock objects were used as teaching aids. A tent could also be seen as a truncated cone — so how much cloth would be needed to make the tent? Barrels were used to find the value of pi.

Commercial arithmetic also used relationships, such as that employed in the well-known ‘rule of three’ (also called the ‘golden rule’ and the ‘merchant’s key’). To work out the cost of 5 units of cloth when 7 units cost 9 lire, you multiply the thing you want to know by the similar thing, and divide the product by the remaining thing’. Thus:

5 units of cloth \( \times 9 \text{ lire} = 45 \quad 45 \div 7 = 6\frac{3}{7} \text{ lire}

The sum was usually done to show how the segments of the calculation related to each other:

\[7 \rightarrow 9 \rightarrow 5 \rightarrow 6\frac{3}{7}\]

This is essentially a rule of proportion, a pragmatic approach to calculation in a society where reckoning was done by eye, on the spot in the market-place.

The Italian of the late fifteenth century was familiar with the use of figures. He bought books about maths and made up games and jokes with it. He took measure of the world with a practised eye. This interest in numbers originated with the Greek philosophical cult started by Pythagoras, who believed that the mysteries of the universe could be penetrated and understood only through the use of magical numbers and their interrelationships. Florentines, reading his works for the first time, shared his view.

Modern Western music, beginning at this time in Italy, employed the Pythagorean scale. Using four strings of equal consistency, 6, 8, 9 and 12 inches long, the octave was produced, as well as its major divisions. The 6 and 12 inch strings were an octave apart, the 8 and 12 inch ones separated by a fifth. The 9 and 12 inch strings formed the fourth, and the 8 and 9 inch strings were separated by a single note. When people of the fifteenth century talked about ‘the music of the spheres’, or the mystical heavenly sounds of Aristotle’s universe, they meant it to be taken literally. Music and numbers were one and the same thing.

This society — numerate, superstitious, emotional, cruel and egotistic — was ideally placed to recover fastest from the economic devastation of the plague. Italy was sited exactly between northern Europe and the Near East. She took the products of the north — gold, grain, leather, wine, textiles — and carried them to the Black Sea and the Levant where they were exchanged for spices, silks, cotton and luxury goods in general. By the end of the fourteenth century the great Italian maritime republics of Genoa, Venice, Pisa and Livorno had bases all over the eastern Mediterranean, and there were regular departures for the Baltic.

What helped to give the Italians, and in particular the Florentines, control over these vast amounts of money and goods was their monopoly of the latest
accounting system. Leonardo Fibonacci, a Pisan who had been brought up in North Africa in what is now Algiers, had introduced the full range of Arab and Indian decimal calculation. The notation was called ‘letters of sand’, due to the original habit of on the spot calculation in a sand tray. Fibonacci had also brought in a new Arab method of balancing income and expenditure. European accountancy at the time was a primitive affair. The merchant tended to treat each transaction as a separate entity. A paragraph giving details of the deal was followed by a space for later notes about costs, interest, sales, and so on. Little attempt was made to bring all transactions together into a comprehensive statement of budget. In the fourteenth century Fibonacci’s double-entry system made a tentative appearance, first in Genoa and then in Venice. But it was the Florentines who were to take the most advantage of the system.

In 1397 the Medici family started lending money on an international scale. Others had tried it before. In the years before the Black Death the great Bardi, Peruzzi and Acciaiuoli families had been bankrupted by the English and Neapolitan royal families who had defaulted on massive debts. But by the end of the fourteenth century the general economic recovery from the effects of the plague was demanding more flexible financial systems. The Medici opened banks throughout Europe, providing a stable exchange rate, a regularity of service based on their branch managers’ ability to take independent decisions, and, above all, their efficient double-entry book keeping methods. Without these, the complex problem of a high level of cash flow coupled with varying exchange rates would have proved impossible to handle. The Medici dominated the money market in Europe because they could balance their books.

This late fourteenth-century miniature shows a group of Genoese bankers with a Jewish financier (second figure from right). The Italian economy was so strong at the time that its coinage was accepted all over Europe. On the wall is a textual reminder of the sin of usury. Only Jews were supposed to charge interest.
Although the rest of Europe was beginning to share in the boom – manifested in an unprecedented scale of building projects, such as the late Gothic churches of Ulm Minster in Germany and Louth in England with their unusually high spires – it was in Italy that the recovery was most spectacular. This was the era of the Doge’s Palace in Venice, of the Palazzo della Ragione in Padua, of the Palazzo Pubblico in Siena with its admonitory frescoes illustrating the effects of good and bad government.

To the ambassadors from northern Europe, accustomed to their vast tracts of waste land and deserted farms, Italy must have seemed positively overcrowded. The population of Venice topped 100,000, as did that of Naples. Florence and Rome held over 40,000 people, and so did Paris. In Germany few towns had a population of more than 20,000. And Italy dazzled all visitors with its extravagance and elegance. Italian was the lingua franca of fashion.

Europe was already affected by the disappearance of Latin as the universal language, due to the growth of sovereign states and the consequent fostering of local vernacular. Even the Roman Curia was no longer insisting that everything be written and conducted in Latin:

The generation of men shall come to such a pass as not to understand each other’s speech. . . . Who will understand the different languages? Who will rule the diverse customs? Who will reconcile the English with the French, or join the Genoese to the Aragonese, or conciliate the Germans to the Hungarians and Bohemians?

And as the universities proliferated, it was no longer necessary to go to a foreign country to obtain a higher education.

Amid these burgeoning local achievements, Florence stood out above the rest. One-third of the city’s population worked on the production of fine Florentine wool, selling it all over the Continent as fast as it could be produced. The first income taxes were being levied, and a census of property was to be taken for the first time anywhere in Europe, so that a form of wealth tax could also be raised.

This was the time of the entrepreneur, as new trading opportunities brought new families into positions of power hitherto the prerogative of aristocrats. Florence was republican by the mid-fourteenth century, and the power of the state was growing mightily. The guilds fought the hereditary noble families for political pre-eminence.

Because the northern Europeans were rapidly learning from the Florentine example, the Italian traders moving across the Mediterranean needed state support if they were to fight off this new challenge. In 1393 came the first major imposition of tariffs against foreign cloth in Florence and its markets. That same year it became illegal to carry Florentine goods on non-Florentine ships. Export of gold coin over 50 florins was prohibited.

To manage all the new regulations, more officials were needed. Between 1350 and 1400 the number of bureaucrats in Florence quintupled, as did the number of lawyers, notaries and accountants. Eighteen civil servants were needed to collect one customs toll; fifty-eight commissioners handled contracts with
mercenary troops (the Florentines were too busy with trade to do their own fighting). Even the freedom of the Church was curtailed. In the 1380s the Tuscan clergy lost most of their medieval liberties and immunities. The Church started making regular contributions to the communal treasury. Church lands were confiscated. The religious fraternities, once so powerful, were virtually under state control, with a lay captain appointed to govern them.

Opportunities in the city were so attractive that many landed magnates, powerful in their local country villages, changed their names and became franchised urban commoners. The new virtues were pragmatism and commercial acumen. Pomp and circumstance were left to the old-fashioned northerners, with their absurd antiquated orders of chivalry.

As the climate became more egalitarian, state control grew until it dominated every aspect of life. State officials regulated the value of gifts that could be exchanged at a marriage, the fines for prostitutes found working in unauthorised areas, the price of fish, the premiums due on dowry insurance. With the state’s new financial commitments, the Public Debt grew out of all proportion. The Monte di Pieta, originally set up as a pawnbroking institution in the days when lending money was against the rules of the Church, was now a sophisticated organisation handling the debt, and offering an 8 per cent ‘gift’ to its shareholders.

Florentine power was underpinned by wealth derived from cloth production. Here a fifteenth-century miniature shows a local lady being measured for a dress. The unshaven tailor is a reminder that razors were an expensive commodity at the time.
Between 1345 and 1427 the number of shareholders increased twentyfold. The 1427 property census showed that almost everyone worth more than 5000 florins had a stake in it. Many of them had little choice in the matter. From 1390 on, the state adopted the system of enforced loans. That year they took half a million florins. In 1400 the figure had risen to 1,200,000, and the total of the Public Debt – 8,500,000 florins – was seven and a half times the commercial wealth of the entire city. Every affluent Florentine had a vested interest in the welfare of his community. The days of revolution were over. No ruler invited to command Florence had much time left for radical change after he had finished administering the apparatus of bureaucracy and the massive debt.

Money had become the key. ‘Down with the hypocritical clerics,’ people said, ‘preaching against worldly wealth. Listen to them, and the fabric of society will fall apart.’ The Florentines were shareholders in the first giant corporate state in Western history. In such a state the talented individual had many opportunities to express his skills – within certain limits. Commissions were set up to investigate and if necessary to execute those who acted against ‘the interests of the state’.

The backbone of this new community, half democratic, half totalitarian, was the middle class. And what these new men wanted was social recognition. Since they could not look to their own ancestry for social status, they transferred the source of their pride on to the state itself. Civic pride would give them all the
public recognition they needed. Religion was relegated to being a private matter. 'Man is weak,' they said. 'Perfection can only be attained by the community.' It was the state that would confer nobility on the citizen. The public world conceived in these terms offered attractive possibilities for happiness and virtue that would be denied those who preferred to lead an individualistic, isolated life. Dignity and stability were the new accolades. Labour and wealth were sanctified because of their public value.

These new attitudes were vital to a burgher class that, with the disappearance of the guilds, had lost the protection it had enjoyed during the Middle Ages. Civic values would give recognition to the successful merchant, the serious scholar, the pragmatic man who could handle life as he handled his business. The new politics and the new view of social and private living enhanced the sanctity of a stable marriage, pride in civic contribution, the free exchange of ideas for mutual benefit, the happiness of community existence. Such a life-style would have seemed to us to exhibit the worst excesses of the nineteenth-century company town.

The Florentines’ only problem was how to provide their new, dynamic, bourgeois capitalism with intellectual and aesthetic credentials. The solution was to come, indirectly, from the Turks. As the fourteenth and fifteenth centuries advanced, so did the spectre of Muslim invasion from the expanding Turkish empire.
In a series of disasters the Western armies were annihilated before the Janissaries and their fanatical troops. In 1396 the greatest crusading army Europe could muster met the Turks at the battle of Nicopolis on the Black Sea, during which the flower of Western aristocracy was slaughtered. The cousins of the King of France, the heir to the Duke of Burgundy, the Marshal of France and other high-ranking members of European knightly families were captured. It seemed that nothing could stop the approaching holocaust.

The most concerned man in Europe, because he was closest to the threat, was the Byzantine Emperor, Manuel II Palaeologos, who sent an academic called Manuel Chrysoloras to the West for help. When the mission failed because the Pope was as keen to see the destruction of Eastern Christendom as was the Turkish Sultan, the rest of Chrysoloras’ entourage returned to the East. Chrysoloras, however, accepted the offer of the Chair in Greek at Florence University, and in 1397 settled there for three years.

His pupils were to be among the most influential in the Florentine state. One of them, Leonardo Bruni, was to rise to the chancellorship. Among the others were major intellectuals such as Poggio Bracciolini, Niccolo Niccolí, and the most famous of teachers, Vergerio of Capodistria. Chrysoloras taught Greek, and thereby gave the Florentines a thirst for classical culture. A group of influential businessmen got together for regular classes in Greek culture, and in 1400 they arranged a package tour to Constantinople. Not everyone who visited the Greek capital was impressed. Ciriacò came back saying it was ‘a museum inhabited by a lot of people beneath contempt’. But in general the Florentine middle classes were impressed. And the contact with Byzantium stimulated an already growing interest in things Roman.

The mathematician Franciscan Luca Pacioli showing an example of Euclid’s plane geometry to a noble pupil. Pacioli’s major contribution to Renaissance Europe was his treatise on double-entry book keeping.
The more wealthy Florence became, the more she began to compare herself with classical, republican Rome. Since medieval times there had been a strong Latin-speaking culture among the lawyers and notaries. Now, excited by the Greek example, they too began looking to the classical past for the glory that would be Florentine. Manuscripts were sought all over Europe. Many were found, in monasteries isolated among the mountains. This time, the parchments were scanned not for the scientific and legal expertise sought by the scholars of the twelfth and thirteenth centuries, but for new models of elegant living. It was the literature, the examples of decorum, the heroic ideal that the Florentines were seeking.

Petrarch had laid the groundwork decades before. ‘After the darkness has been dispelled,’ he wrote (the darkness he spoke of was the medieval period), ‘our grandsons will be able to walk back into the pure radiance of the past.’ The more they looked at pre-Christian classical thought, the more the Florentines found what they wanted: the civic glorification of the community-conscious individual. The Romans and Greeks were not to be regarded as paragons of knowledge, but as paragons of excellence. At the core of their writings, in the rhetoric, education, poetry, morals and philosophy, the central figure was not Christ, not the transient, worthless figure of mankind as described by the medieval theologists, but man – independent, intelligent, adventurous, capable.

This concentration on the human rather than the divine, an attitude which became known as humanist, was to characterise the next hundred years of Florentine and European thought. The new type of man lived a life that was positive, a life full of the beauty and dignity inherent in the natural world. Man was now thought capable of finding his own salvation through sober conduct and systematically decent morals, rather than through the performance of mystic church rituals. The ascetic in the cave was gone. In his place was the man of the world.

That world, of business and social mobility, had need of the new values. The humanist view found ready acceptance in schools. Some of the great teachers
had sat with Chrysoloras; others were ready to follow. In 1404 Vergerio, one of Chrysoloras’ pupils, wrote a treatise on education at the university of Padua. In it he upturned medieval ideas for good. It was less important, he said, to impart knowledge than to foster character in the pupil. The typical pupil he had in mind, of course, was the merchant’s son who needed to please his father’s colleagues by showing ambition and a competitive attitude and paying strict attention to business matters. Vergerio had learned the Byzantine love of detail, which so aptly fitted the business world. ‘Always take notes,’ he advised.

Two other men led the way. Both were teachers and both went to the new humanist courts: one to that of the Gonzaga family in Mantua, the other to the Este court in Ferrara. Vittorino da Feltre and Guarino da Verona taught the children both of their noble masters and of the poor. They prepared their charges not for the Church but for public life, teaching grammar, poetry, rhetoric, history and moral philosophy from classical texts. As Vittorino said, ‘Not everybody is called to be a lawyer, a physician, a philosopher . . . but all of us are created for the life of social duty, all of us are responsible for the personal influence which goes out from us.’

The new attitude was reflected in the curriculum. The old subjects of formal rhetoric and public speaking were replaced first by prose composition, then letter writing, then business administration through the _ars dictaminis_, where the pupil learned to dictate a closely reasoned report or letter to his scribe.

The secular wave brought to the fore an interest in history. Another of the new bourgeois yearnings was to have illustrious forebears. For the first time European society became aware of a documented past. Reading the classical authors revealed a sophisticated civilisation that had existed before the ‘medieval darkness’ described by Petrarch. The legend arose that Florence had been founded by the troops of Julius Caesar, rather than, as the old story went, by Charlemagne, semi-magical progenitor of most of medieval Europe!

However advanced this humanist outlook may seem, it must be remembered that there were still few tools with which to give concrete expression to the new-found confidence of Florence. Nature was still seen as mysterious and symbolic, whether the Romans and Greeks had thought so or not. Then, some time in the first or second decade of the fifteenth century, everything was to change, thanks to a young man returning from his studies at Padua University. His name was Paolo del Pozzo Toscanelli, member of a well-known and successful family of spice traders in Florence, and he had gone to Padua to get a medical education.

Padua was the place to which most of the supporters of Averroes had fled in the thirteenth and early fourteenth centuries, so as to continue teaching his philosophy of the empirical investigation of a universe which was seen as a machine-like creation obeying rational laws. The city had maintained its independent intellectual tradition principally because it had been taken by Venice in 1404. Venice was the most powerful state in Italy, dealing as an equal with Constantinople, England and France. She was also, and more important in this context, anti-clerical and anti-Pope. Under Venice, liberty of speculation and teaching was guaranteed.
Brunelleschi’s famous dome on Florence Cathedral. The construction, unequalled at the time in architectural genius and engineering skill, dwarfed the city and served to provide its citizens with the status symbol they so earnestly desired.

Toscanelli was born in 1397 to a well-to-do bourgeois family which owned nineteen servants, two horses and a mule. One evening, probably in 1424, Toscanelli was in Florence, having returned from Padua, where he had among other things studied under the great mathematician Biagio Pelecani of Parma. At a dinner party held in a friend’s garden, Toscanelli met the man with whom he was, as he himself said, to form ‘the greatest association of my life’. The man in question was Filippo Brunelleschi, a local architect and builder, who was at the time engaged by the comune on the construction of a dome for the unfinished cathedral. The difficulty Brunelleschi faced was one he had set himself: how to construct a circular structure over an octagonal base.

Brunelleschi’s experience was purely practical. He had studied no Latin. What little he read would have been limited to Dante and the Bible, both in the vernacular. At this time an architect was still a craftsman, rather than a theoretician. Buildings were still being planned and constructed empirically. The planners of Milan Cathedral had recently spurned the use of calculation because it did not fit the Aristotelian view of what could be done in building – which was simply to double the number first thought of when it came to designing for strength. Many buildings collapsed.

At the dinner in Florence, or soon after, Toscanelli opened Brunelleschi’s eyes to the geometrical possibilities of his university knowledge, and the two men probably joined in the task of designing the dome. Brunelleschi developed a method of constructing it with little use of wood for scaffolding, and without any centring. This had never been achieved before. The idea undoubtedly came partly from the weeks Brunelleschi had spent earlier in Rome with Donatello, meticulously examining and measuring the Roman ruins to see how triumphal arches, barrel vaults, tunnel vaults and coffered roofs could be built for their nouveau riche Florentine patrons. The two had spent so much time underground that the Romans presumed them to be treasure hunters. The trip to Rome was but one example of the general research into the past going on in various fields.

The civic aim, extolled by another architect, Leon Battista Alberti, in a remark about Brunelleschi’s dome, was revealed:

Who could ever be hard or envious enough to fail to praise Pippo [Filippo] the architect on seeing here such a large structure, rising above the skies, ample enough to cover with its shadow all the Tuscan people, and constructed without the help of centring or a lot of wood? Since this work seems impossible to achieve in our time, I reckon it was probably unknown and unthought of to the ancients.

The dome was not completed until 1436, but as it rose it served to remind the Florentines that they were doing something better than the ancient Romans and Greeks. They were not merely copying: they were fusing the old tradition with a new dynamism that was solely Florentine.

What was to prove the most dynamic act of all, however, was due to another facet of the Toscanelli–Brunelleschi relationship. While Toscanelli had been in Padua, his teacher Biagio da Parma had given a course on optics. In this he had drawn on the writings of the great Arab thinker Al Hazen.
Born in Basra in AD 965, Al Hazen had written on every aspect of optical tradition, drawing on the earlier work of Aristotle, Galen, Euclid and Ptolemy. In the tenth century, theory held that the eye gave out a ray of light which acted in various ways, according to different schools of thought, to hit any object in its path and send the image of the object back to the eye. Al Hazen disagreed. If bright light gives pain, he argued, how can the eye make bright light? And if everything is lit up by the eye, the eye must contain enough light to illuminate the entire field of view after every blink.

Al Hazen held that light came from sources of illumination such as candles or the sun and was then reflected off the object, carrying its image to the eye. Since light rays from many objects would thus enter the tiny pupil of the eye, it must in some way be able to focus them. The eye, therefore, had to be at the apex of a cone of light made up of visual rays from every part of the eye’s field of vision. Taking the analogy of a straight sword-cut going deeper than an oblique one, Al Hazen stated that the ray perpendicular to the eye was the strongest. He called it the ‘centric ray’.

Al Hazen’s theory had an extraordinary influence in the West among leading scholars such as Roger Bacon, John Pecham (Archbishop of Canterbury) and, in particular, Witelo, the Polish cleric and scholar, from whose writings Biagio da Parma had received it.

Biagio’s lectures were entitled ‘Questions on Perspective’, and as was the way at the time, Toscanelli had taken notes. He explained their content to Brunelleschi, whose initial interest may have been purely practical. The mathematics of perspective might make it possible to draw three-dimensional elevations of building plans for his clients, and this would enormously enhance his reputation as an architect. It may have been while working on such a plan that Brunelleschi carried out an experiment which was to prove one of the most fundamental in the history of Western thought.

At this time in the early fifteenth century, the glassworks on the island of Murano in the Venetian Lagoon had just started producing the new, flat, lead-back mirrors. Toscanelli showed Brunelleschi how this mirror exaggerated the perspective of the objects it reflected, because when you swivelled the mirror from the perpendicular position in front of the eye, what Al Hazen would have called the ‘centric’ position, the way in which objects diminished in size as they receded was very evident.

Brunelleschi put this idea into practice. He set up a mirror about six feet inside the main door of Florence Cathedral, facing outwards so that he could see the Baptistery, across the square, in the mirror. He then painted this reverse image on to a flat wooden tablet. Then he drilled a hole in the centre of the painting. Viewers were invited to look through the hole in the back of the painting while holding the mirror at arm’s length in front of the painting, so as to see it reflected in the mirror. As they were standing facing the Baptistery at the time, when the mirror was removed, they continued to see the Baptistery. Such was the accuracy with which Brunelleschi had done the painting that there was no discernible difference between the mirror-painting and the real thing.
This was the first example of perspective painting, and it must have had an extraordinary effect on people accustomed to the non-perspective representational styles of the period. Brunelleschi had chosen the Baptistery because its height, width and distance from the cathedral were almost exactly the same. Because of this the perspective ratio of all three dimensions was easy to reproduce—it was 1:1:1. By putting the peep-hole exactly where the eye level of the viewer would be while looking at the real Baptistery in the same position as he had chosen to paint, Brunelleschi had ensured that the painting faithfully showed all objects in their correct perspective to the viewer. The effect was that of looking through a window at a real scene.
This was precisely the effect captured by the first commissioned perspective painting executed later the same year by Brunelleschi’s young friend Masaccio. The painting still stands on the wall of the church of S. Maria Novella, in Florence. It is called The Trinity, and it is the first example of the new art. The view is as if seen through a window into a chapel. The barrel vaults and coffered ceilings are mathematically exact, as though they were blueprints for construction. The perspective is enhanced by the introduction of figures at different stages ‘into’ the painting. And the lines Masaccio scratched on the wall as his perspective ‘plan’ are still to be seen today. The centric point of the painting is at 5 foot 3 inches from the floor, the average height of Masaccio’s Florentine spectator. The subject of the Holy Trinity, imbued as it was with geometric symbolism, may be evidence of the new feeling, expressed elsewhere, that mathematics would become the tool with which to explain the universe and find the way to God.

As has been said, Brunelleschi was a semi-literate craftsman. He was more at home setting up the canteen for his staff, arguing with their union about terms and conditions, hiring and firing, than he was at making his revolutionary technique interesting to the scholars and intellectuals who anyway held his position as an architect in little esteem.

His academic champion turned out to be the architect and mathematician Alberti, an ex-scribe to the Pope. Alberti took Brunelleschi’s perspective geometry, dressed it up in Latin with appropriate classical references, and made it thoroughly acceptable. He also made the geometry easy enough for any painter or architect to follow. He began with a fine cotton veil, in which criss-cross threads formed a kind of grid. When this grid was held up between the painter and the scene, each object would be seen to occupy more or less grid space according to its relative size and distance from the eye. Painting by grids would ensure correct relative proportion in the end result.

Alberti then moved to the technique for painting a scene from the imagination, using perspective geometry to place everything in correct proportion according to its position in the scene. Initially this was demonstrated by placing a series of gridded veils between the painter and a scene. Figurines of the same size, placed at varying distances from the eye, were connected to the front grid by threads. From the painter’s viewpoint, these threads appeared to converge at a single point to the rear of the scene. This was Al Hazen’s ‘centric point’. Alberti called it the ‘vanishing point’.

To reproduce the necessary guidelines on the wall to be painted, a geometric design had first to be drawn along these lines. A frame was chosen, with the horizon line drawn across the rectangle of the frame at the height of the viewer’s eye. The base was divided into an equal number of spaces. Lines were then drawn from these points to the mid-point of the horizon line. The same was done at the upper edge of the frame. These lines radiating from the centric point provided a framework on which all objects could be drawn, correctly positioned and in proportion to their distance from the front of the scene.

The use of a ‘pavement’ on the floor of the scene, to enhance the feeling of perspective, was achieved with further geometry. The base of the frame was
A Dürer woodcut showing a painter studying the first stages in the technique of reproducing a foreshortened view—in this case of a lute—which he has achieved by attaching the 'sighting' thread to various points of the object and tracing the points on a screen.

extended to one side by the distance of the viewer's eye in front of the painting. A vertical line was then drawn from the outer end of the line to a point level with the horizon line, and this point was joined by lines radiating out across to the division points on the base of the frame. The same was done on the other side. When all these lateral lines crossed the lines running from the base to the centric point, they formed rectangles shaped strictly according to the perspective required by the viewer to achieve the full illusion of depth.

While Alberti still did not know enough about optics to say more than that the outer rays from the objects gave their shape, and the inner ones their colour, he saw that the plane where the observer placed the grid was on a plane intersecting the visual pyramid Al Hazen had described.

What had been achieved was a revolution in the way people looked at the world, not just in terms of visual representation but from a philosophical point of view. Following the discovery of perspective geometry, the position of man in the cosmos altered. The new technique permitted the world to be measured through proportional comparison. With the aid of the new geometry the relative sizes of different objects could be assessed at a distance for the first time. Distant objects could be reproduced with fidelity, or created to exact specifications in any position in space and then manipulated mathematically. The implications were tremendous. Aristotelian thought had endowed all objects with 'essence', an indivisible, incomparable uniqueness. The position of
these objects was, therefore, not to be compared with that of other objects, but only with God, who stood at the centre of the universe. Now, at a stroke, the special relationship between God and every separate object was removed, to be replaced by direct human control over objects existing in the same, measurable space.

This control over distance included objects in the sky, where the planets were supposed to roll, intangible and eternal, on their Aristotelian crystal spheres. Now they too might be measured, or even controlled at a distance. Man, with his new geometrical tool, was the measure of all things. The world was now available to standardisation. Everything could be related to the same scale and described in terms of mathematical function instead of merely its philosophical quality. Its activity could also be measured by a common standard, and perhaps be seen to conform to rules other than those of its positional relationship with the rest of nature. There might even be common, standard, measurable laws that governed nature.

Meanwhile, the confidence that the discovery must have raised in the Florentines began to make itself evident. If man were the measure of all things, then all things must surely relate to the measure of man: his experiences, his observations, his points of view.

The church of S. Lorenzo, Florence, built in 1423 to a design by Brunelleschi which was made strictly according to the principles of perspective. The vanishing point and focal centre of the building as viewed from the entrance is the holy tabernacle on the altar.
Painting became more realistic in subject-matter and style. The desires of the middle-class patrons of art had now been sanctified by the new philosophy. As the number and wealth of the patrons grew, so did the independence of the artist. Now it was said, ‘Pigliare buna maniera propria per te’ (paint in your own personal style). Hitherto this would have been meaningless advice. Individual, subjective views of the world had been irrelevant, even theologically risky, but with the rules of perspective established they were on safer ground.

In 1420 about 5 per cent of paintings were of non-religious subjects. A century later the proportion had risen to about 20 per cent. Subjects now were taken from the classics rather than the Bible. The figures of saints became smaller, while the background became more important. There was an increasing amount of portraiture, as mirrors and the new realism encouraged the merchant to enhance his own importance with paintings of himself and his family.

There were still curious hangovers from the old ways, however. The Benedictine rules for silent communication by gesture were still shown. Affirmation was expressed with the back of the hand towards the viewer, demonstration with the palm towards the object indicated, grief with the palm pressed to the heart, shame by the hand covering the eyes. (In Masaccio’s Expulsion of Adam and Eve, Eve’s culpability is shown by the fact that she

Above: Masaccio’s fresco, The Expulsion of Adam and Eve (c. 1424-8), in the Brancacci Chapel, Florence.

Mantegna’s fresco in the Ducal Chamber of the Ducale Palace, Mantua, shows Ludovico Gonzaga and his wife Barbara of Brandenburg with members of their family. The style is extremely realistic, conversational. Note one of the court dwarfs, bottom right.
merely expresses grief, while Adam shows shame.) Welcome is shown with an extended hand, palm out, fingers drooping.

In the great frescoes by Mantegna in Mantua, illustrating the life of his royal patrons the Gonzagas, the style is extremely naturalistic. The scenes are lifelike and casual. There is no narrative, merely a moment captured for the record. By signing his work, Mantegna enhanced the concept of art as witness to everyday life. The subjects in his frescoes are portrayed eating apples, holding hands, talking in asides to each other.

When Federigo da Montefeltro had his portrait painted, this brilliant general chose to show himself reading a book, or at home or on embassies, never at war. This growth in the sense of individualism is also seen on a grander scale. Around Federigo’s courtyard in the great Ducal Palace at Urbino, where he lived, is carved, ‘I am Federigo . . . and I built this place’.

In literature, too, writers began to express themselves more personally. The new interest in psychology produced biographies of ordinary men and women, no longer only of the saints. The first novella appeared, stories treating of people and their daily lives. Drama moved away from the church and religious subjects into the theatre. Secular music in the form of madrigals, with the solo line heard above the other parts, was now played in the home. Instrumental pieces were also being written for the first time.

Raphael’s School of Athens (1511), a major, dynamic work of the new perspective painting. The pavement lines and the receding arches enhance the realism of the scene, heightened by the way the figures are cut off at the edge, as if more would be visible if we were to move in through the arch.
The Malatesta church in Rimini, where Alberti’s design was imposed, in 1450, on an earlier building. The central triumphal arch supports the Roman-style inscription above, which identifies the patron, Sigismund Pandolf Malatesta.

But the most obvious example of the change in attitude is, of course, to be seen in architecture. The fact that classical forms were employed was due not so much to the new perspective as to the earlier interest in things humanist. The Florentines had little time for Gothic styles. In fact, the term itself was invented by one of them as a contemptuous description of the period that lay between them and ancient Rome — ‘middle ages’ when barbarian influences were introduced by the invading Goths.

Florence looked for a substitute tradition and found it in classical antiquity. The classical orders, Ionic, Doric and Corinthian, were adopted in architecture. Triumphal arches were erected. (One survives today on the front of the Malatesta church in Rimini.) The portrait bust and the equestrian statue were eagerly sought by the Florentine nouveaux riches. Imitation Roman coffered ceilings replaced arched vaults.

But all this was peripheral to the central change in style which dictated that buildings were now to be constructed with man as their focal point. The scale of the building had to relate to the human observer and his point of view. The first manifestation of this change was the centre-plan church. It was essentially a pagan style, since it broke the long-held liturgical rule that clergy and laity were to be separate.

In about 1450 Alberti gave overall direction for the construction of these new churches. He said that the church must stand on elevated ground, clear all round, in a beautiful square, isolated by a high base from the surrounding flow of everyday life. The facade had to have a portico or colonnade. The vaults must
be of the purest colour, preferably white. Ideally there should be statues rather than illustrations on the walls. The pavements should have lines and figures illustrating music and geometry. The windows should be so high that no contact was possible with the outside world.

The first and most perfect example of Alberti’s rules and of the effect of Brunelleschi’s discovery of perspective is the church of S. Maria delle Carceri in Prato, a few miles from Florence. Probably designed by Alberti, it was begun by Giuliano da Sangallo in 1485. This centre-plan church introduced the form of the Greek cross. In the medieval world the cross had signified Christ crucified. Here the classical cross was used to give a sense of mathematical purity. Where Gothic had led mysteriously to the high altar and the towering spire above it, this new church invited rational evaluation. The exterior of S. Maria is formed of limestone slabs, divided into geometric units by green framing bands. The joints of the building are marked in pietra serena, grey stone, while the rest is white. Under the dome one stands at the centre of the church, and all around is harmony and proportion. It was this exact use of balance that showed the influence of perspective. Proportion was all. Alberti gave exact specifications for all churches. The height of the wall up to the vaulting should be half, two-thirds or three-quarters of the diameter of the plan. These proportions, of 1:2, 2:3 and 3:4, should dominate the structure. At S. Maria the four arms of the cross are equal in length. The depth of the arms is half their length. The four end walls are as long as they are high.
Alberti's façade of S. Maria Novella, Florence, finished in 1470. The medieval bell-tower of the church can be seen in the background. The scrollwork on either side of the upper storey was the first move towards the florid, baroque style of the next century.

The use of proportion is best seen in Alberti's design for the façade of S. Maria Novella in Florence. The new front was added to a Gothic church. Alberti obeyed his own injunctions. The front is a square, and the upper and lower storeys divide it in half. The upper storey of the façade is precisely half the total upper storey of the church. The lower storey is symmetrical about each half of the lower rectangle. The upper central bay, half the total upper area, is exactly split above and below the entablature. Half of this is equal to the width of the upper side bays. Up to this point everything is in the ratio 2:1. But the height of the entrance bay is one and a half times the width. So the width to height ratio is 2:3. The dark, square encrustations of the attic are one-third the height of the attic and relate to the column diameters in the ratio 2:1. The entire façade is geometrically built up in a progressive halving of ratios. It is the first great example of Renaissance *eurhythmia*, proportion.
The rules for the building of cities were equally concerned with proportion. Cities were to be the mirror of a harmonious universe, with buildings arranged according to function. These would be of three types: public buildings, for the princes; buildings for the wise, experienced, wealthy citizens, like Alberti’s Palazzo Rucellai in Florence; and decently constructed buildings for the poor. Throughout the city plans, man was the standard.

At the village of Corsignano, in Tuscany, the birthplace of the humanist Pope Pius II, the Pontiff ordered a town to be built according to the new rules, to be called Pienza. The architect was Bernardo Rossellino, who, among other things, asked that anybody who painted or in any way adorned the inside walls of the cathedral should be punished. The little town of Pienza still stands virtually as it was built, according to Alberti’s rules of symmetry. The square is perfect.

Pienza is only one example of the increasing involvement of the authorities in public projects. The contract for the doors of the Florence Baptistery was put up to competition, to be judged by a panel of thirty-four experts, some of whom came from outside the city. Guilds commissioned the statuary for the guild church of Or San Michele. One of the statues is Donatello’s St George, the first of an entirely new kind of sculpture, showing the hero as a human being, with human characteristics clearly marked. The Silk Workers’ Guild financed Brunelleschi’s first major work after the Dome, the Foundling Hospital, finished in 1424. Above all, patronage by the wealthy Medicis was at work everywhere. Cosimo de’ Medici paid for Michelozzo’s Palazzo and the Marciana, the first public library in Italy.

New town planning permitted towns to be custom-built. The Italian town of Palmanova was constructed in one piece as a fortress in 1593. The radial streets centring on the command post ran directly to the bastions, affording ease of movement for troops and munitions along the wall.
A portolan chart of 1374, produced by the great Catalan cartographers. Nothing is known south of Cape Bojador. Mariners’ interests are served by the criss-crossing wind lines and the detailed attention to coastal landmarks. Inland country is virtually unmapped.

Parallel with these developments ran a series of events that started where the original use of perspective had begun – with cartography. Once again, this was triggered by the growing Turkish threat. Two groups of people had paramount interest in solving the Turkish problem. The first was the Byzantine Emperor. After the failure of Manuel II Palaeologos to raise money and aid for the defence of Constantinople, his grandson John tried again. By this time the situation was much more serious.

John offered to heal the breach between his church and the Roman Papacy. He agreed to send delegates to a council to discuss some form of ecumenical solution to the schism between East and West. The Roman Pope, Eugenius IV, was in a strong position to dictate terms, since the Turks, in Thessaloniki by 1430, were now almost on John’s doorstep.
The Council met first at Ferrara, and then, when Florence offered to pay all expenses, it moved there. On 6 July 1439 over five hundred delegates assembled at the church of S. Maria del Fiori to open the Council. Significantly for what was to follow, some of them came from Jerusalem, Rhodes, Trebizond, and remote parts of Africa and the East.

The other people with a vital interest in solving the Turkish problem were Toscanelli and the Portuguese King. Toscanelli’s family had been traders in spices for several generations and were concerned that if, as seemed likely, the Turks cut off the route to the East by occupying Constantinople, either supplies would stop coming or the Turks would charge exorbitantly for being the middle-men. This would have the effect of destroying the market. The King of Portugal was also interested in the spice trade. His country had been trying for decades to find alternative routes to the Spice Islands, off the Malay peninsula. As early as 1415 they had begun exploring the west coast of Africa, and had already colonised the Canaries, the Azores and Madeira. In 1419 Prince Henry, known as ‘the Navigator’, set up a school of navigation at or near Sagres, Cape St Vincent, the westernmost point of Europe. As a good Christian he wanted to carry the Church’s message to the African natives and hoped to find the legendary Christian ruler of central Africa, Prester John. He also wanted to feel out the territorial limits of Muslim power on the continent and to develop new trade routes, in particular with a view to finding another way to the Spice Islands of the East.

In 1425 Henry’s brother Dom Pedro had visited Florence to pick up maps and geographical material which he had ordered and also, he hoped, to collect the considerable sum of money which the city owed the Portuguese. He had made contact with Toscanelli, whose family business had a branch office in Lisbon. But Pedro came to Florence principally because by then it was a thriving cartographical centre.

The Florentine interest in cartography had been stimulated at the beginning of the century when the group of businessmen to whom Chrysoloras had originally taught Greek, who had been on a tour to Constantinople in search of culture and classical texts, had returned in 1400, after shipwreck and adventure, with a copy of the greatest cartographical text of antiquity, Ptolemy’s Geographica.

Coming as it did at the high point in the early development of humanism, the book created a furore. Many de luxe editions were copied. Besides containing everything known to the Greeks about the earth, the maps in the book were also extraordinary because they were gridded.

The Italians had seen maps before. For over a hundred years they themselves had been using portolan charts – individually produced charts of sections of coastlines, drawn in great detail and carrying the lines of the prevalent winds. But the Geographica mapped the entire known world. Moreover, the material was presented in a consistent and standardised way, with grid lines of latitude and longitude. This metrification of the earth’s surface meant that all points on the map were therefore proportionately distant from each other, and that even unknown locations could be given co-ordinates.
Toscanelli was a doctor and, typically for the period, had also studied mathematics. Besides this he was a cartographer and so well placed to investigate whatever cartographic information might be gained from the delegates visiting the Council. At the request of the Portuguese, Toscanelli began to interview any delegate who could tell him anything about the Far East. While the Council was still meeting, a Florentine trader called Andrea da Sarteano returned from the Persian Gulf with a fellow Italian, Niccolo da Conti, whom he had found stranded in Cairo. Conti had spent years in the Far East.

In the same year, 1441, Portuguese interest in exploration was heightened by the discovery of the African Gold Coast, rich in precious metal and equally valuable slaves. The desire to develop long-distance navigational skills became a matter of some urgency.

When Toscanelli had been studying in Padua years before, one of his classmates had been Nicholas, a German from Kues, near Trier, on the banks of the Moselle. Nicholas too was a mathematician, though his initial studies had been in law. Together with Toscanelli he had been inspired by the mathematical teachings of Prodocimo de’ Beldomandi. In 1437, at the behest of the Pope, Nicholas had gone to conduct the Emperor John to the Council at Florence.

Nicholas had a profound admiration for Toscanelli, whom he considered the best mathematician in Europe, and to whom he dedicated several books. He and
Toscanelli remained in close contact through the years of Nicholas’s steady rise to the position of Cardinal. In the 1440s Nicholas wrote his great *Reconciliation of Opposites*, in which he propounded what was the first relativistic view of the universe.

If the universe is infinite then the Earth is not necessarily, or even possibly at its centre. And if that is so, the Earth may well be circling the Sun. It is only the viewpoint of the observer as he stands on the Earth that makes him think it the centre of the universe. The same would be true of anybody standing on the Moon or on any one of the stars and planets there might be in the universe. And if everything were relative to everything else, the only way to know where you were, on Earth or on a planet, would be to find a way to measure the ‘elsewhere’.

This was precisely what the perspective geometry of Brunelleschi would permit: measurement at a distance. It occurred to Toscanelli that, together with Ptolemy’s gridding system, perspective geometry might be adaptable to the cartography of oceanic sailing where, in the absence of landmarks, some form of standard measure was essential.

On 11 August 1464, in the Umbrian town of Todi, Nicholas of Kues died on his way to Rome to attend the Pope. Toscanelli attended the funeral rites for his old friend, and there he met the Canon of Lisbon, Fernan Martins de Roriz, the confessor of Afonso, of Portugal. He and Toscanelli added their names as witnesses to Nicholas’s will.

Martins at this time was undoubtedly well informed on the Portuguese sailing expeditions because he was in charge of the navigation committee in permanent session regarding the problems besetting exploration of the African coast. The ships’ captains were facing a crisis. The further down the west coast

The new charts broke with Christian tradition too, in displacing Jerusalem from the centre of the earth, as it was depicted in medieval world maps, where Europe and Asia were entirely surrounded by the Great Ocean.

A modern reproduction of what Toscanelli’s map of 1474 may have looked like. Note the critical absence of the American continent. Reports had been received of a land-mass in the Atlantic, perhaps the Azores, here shown as the imagined island of Antilia.
This early map of the New World includes South America, discovered early by Portuguese navigation training ships which had been blown west in the south Atlantic. The presence of a new continent questioned the completeness of revealed truth, since the Bible made no mention of it.

of Africa they went, the lower the Pole Star dropped towards the northern horizon behind them. South of the Equator they would lose sight of it completely, and with it the ability to navigate their way home.

Navigation at the time was principally a matter of finding a destination by taking the angle of altitude of the Pole Star at certain hours, and then ‘running up or down’ the north–south latitude lines. Coming north the navigator would sail until the star was in the right position, then turn east until he came to Lisbon. South of the Equator, the stars were unknown. No altitude tables existed for them. Some other way of navigating had to be found, if the ships were not to lose their way.

The new method took Toscanelli back to his days with Nicholas. If perspective geometry allowed the measurement of an object at a distance, the same might be done with the surface of the earth. The gridding method gave metric coherence. With a regular scaled map to go by, a sailor returning from south of the Equator could sail north by the sun a given number of grid distances, and find his way back by the same method.

As he developed this idea, Toscanelli must have seen its potential application for a greater enterprise about which Afonso’s ambassador had also spoken in Florence some years before. This was the possibility of finding an alternative to the West African route to the Spice Islands. The Portuguese had been undertaking training voyages out into the southern Atlantic, navigating by the
sun. Toscanelli remembered that during his conversations with Conti, the traveller had said that he thought there was a great ocean to the east of Japan. Where was its other edge?

Finally, on 25 June 1474, Toscanelli wrote to Martins, in Lisbon:

I am pleased to hear the King is interested in a shorter route than the African one now being attempted. . . . I enclose a chart showing all the islands from Ireland to India and South to Guinea [Ghana]. . . . the straight lines across the map show the distance East-West . . . the others show the distance North-South. . . . if you go West from Lisbon . . . you get to the fine and noble city of Quinsay [Cathay, China] . . . and . . . to Chipango [Japan] . . . full of gold, pearls and precious stones . . .

Toscanelli's chart was based on an assessment of the circumference of the earth using the value of a degree at the Equator as equal to 75 miles. He reckoned that Quinsay was about a third of the circumference from Lisbon, at the same latitude of 40°N. So he divided his chart up into vertical strips each about 250 miles wide, and showed that the distance from Lisbon to Quinsay by a western route would be twenty-six of these strips, or a total of 6500 miles. As it turned out, his data was inaccurate. He had used the exaggerated size of Eurasia reported by Marco Polo. By his calculations, however, the route west to Japan looked invitingly short.

He sent a copy of the chart to an Italian captain, who in 1483 took it to the Lisbon committee for navigation to the Spice Islands. The committee turned it down. The captain then tried others, including the Spanish court. He failed there, too. Then, as he was about to take ship in order to plead his case before the French court, the Spaniards changed their minds and agreed to support him.

With Toscanelli's map stuck to the flyleaf of his atlas, the captain set sail for Japan. He was never to arrive. On the way west to Japan Captain Columbus discovered America.