A FOURTEENTH-CENTURY COSMOLOGY *

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In 1949 the Library of the Johns Hopkins University purchased a fourteenth-century Latin manuscript entitled *De Macrocosmo*. As far as has been discovered, the manuscript is unique, though there is some evidence that it was copied from a draft made by its author. This evidence consists of frequent repetitions of words and phrases, once in a while of whole lines, which have been eliminated by erasures. This would hardly occur if the original manuscripts had been dictated. If there was an author's original, it has disappeared to the best of our knowledge. The handwriting in the codex appears to be that of an Italian scribe of the fourteenth century, but the illuminations which introduce each book are most probably French and date from the beginning of the fifteenth century. This would not be unusual since itinerant illuminators visited all parts of Europe for just such purposes.

THE AUTHOR

Fortunately we know at least the name of the author and the title of the work. The Prologue begins, *Incipit liber Aurelii Mar [ci] Trivisano Veneti De Macrocosmo, i.e., De Maiori Mundi.* Later we are told that Trivisano was of the Parish of San Marziale in Venice. The work is unfinished and on the last page we learn that its composition was interrupted by the author's death in 1378. We learn also that when he was writing Book V he was fifty years old and that he was forty when he began the work (page 61 verso). In Book IV, when speaking of John Hestenden, he mentions the year 1347. We therefore can conclude that the book as a whole was written, let us say, between 1345 and 1378, though it is more likely that it was begun somewhat later. If we allow the author two years to write what he completed in Books V and VI, we might conclude that he was fifty-two when he died, which would make the date of his birth 1326. That is of course too precise, but we may set his life in the second and third quarters of the fourteenth century.

HISTORY OF THE MANUSCRIPT

As for the history of the manuscript, we have the following information.

(1) Giovanni degli Agostini in his *Notizie istoriche*, Venice, 1752, Volume I, preface, p. xlvii, writing of the library of Apostolo Zeno, says,

> Non meno delle altre scienze, sece figura tra'nostri la Filosofia si Platonica che Aristotelica. Volendo ammaestrare il suo figliuolo Lodovico, Marco Trivisano della Parrochia di San Marziale, compose un Libro, sotto titolo di Macrocosmo, o sia *de Majori Mundo,* che quantumque da X anni ne travagliasse d'intorno, nientedimeno colto da morte nel 1378, non potè a fine condurlo.

This would seem to show that our manuscript, or a copy of it, was in the library of Apostolo Zeno.

(2) How the manuscript came into Zeno's possession we do not know, but we have evidence that it remained possibly for a while in the hands of its author's heirs. In L. Romanin's *Storia documentata di Venezia,* Venice, 1855, Volume III, Book viii, Page 366, appears the following passage.

> Tre Trevisani, Marco, Bernardo ed Andrea, ce si presentano in questo secolo XIV come distinti cultori delle scienze naturali e filosofiche. Il primo, abitante nella parocchia di San Marziale e morte nel 1378, lasciò un' opera intitolata "Macrocosmo" o "De Maiori Mundo," scritta per istrusione di suo figlio Ludovico, nella quale trattava in sei libri delle meraviglie della natura, une specie di Cosmografia, che passata nel secolo scorso nella biblioteca di Apostolo Zeno, venne sciaguratamente a mancare prima che i libri di questo grande erudito pervenissero alla Marciana.

This does not show that Zeno purchased the

* This paper is a brief summary of the contents of a manuscript in the library of the Johns Hopkins University. Thanks to a grant of the American Philosophical Society, I was enabled to make a transcription of this manuscript. The original codex, a microfilm of it, and my typewritten transcription are now on deposit in the Johns Hopkins University Library where they may be consulted by scholars who are interested in fourteenth century science. The purpose of my summary is not to reproduce all the contents of the codex, which would be impossible without an extended translation of the mathematical proofs, but to indicate briefly its purpose and conclusions.

codex from the Trevisano family nor indeed how he acquired it, but in view of his own residence in Venice and the fact that the manuscript was in his possession, there is no reason to suppose that it left the city.

(3) At Zeno's death his library passed to the Marciana, as Romanin points out. In the Marciana there is a *Catalogo dei codici di Apostolo Zeno* (MSS. ital. Cl. CI, no. 285) which carries on the fly-leaf the notation that it was written by Marco Forcellini, "Zeno's collaborator in the last years of his life." The twenty-second entry runs as follows.

Liber Aurelii auctoris Marci Trivisano Veneti de Macrocosmo, i.e., de majori mundo. Comincia il Prologo: Quilibet elevata intellectui rerum ordinem speculanti: finisce: *gratias referans bonorum laugitovi* [obviously a misreading of *largitori*]. Indi comincia il Trattato cosi: *De divisione et compositione continui;* il quale è diviso in sei libri, e termina con queste *parole: productos fuisse planetas.* Trovasi poscià d'altra mano la sequente annotazione: *Adverse quisquis praesens opus inspexeris, quod Dominus Marcus Trivisano de contrata Sancti Martialis Venetiarum hujusmet operis auctor quippe Aurelius, id ipsum non complevit morte praeventus anno Domini millesimo trigentesimo septuagesimo octavo, cujus animam Iesu Christo feliciter commendare dignetur quiscumque in eo legevit Amen.* Codice membranaceo bellissimo, in foglio coll' effige dell' autore in abito patrizio nella lettera iniziale del primo libro, a con fregi di minio ed oro, a varii fiorami anche nelle iniziali degli altri libri. Il carattere è della fine del secolo quartodecimo.[1]

This description answers perfectly, with the exception of two misreadings of single letters, to that of our manuscript. Since neither the description of the manuscript nor the *incipit* has been found in the usual catalogues and lists of Italian and other *codices,* we are concluding that the Johns Hopkins *codex* is that which was owned by Zeno.

(4) This conclusion is somewhat fortified by the following.

In the catalogue of the Marciana appears a marginal note alongside the entry for the Trivisano manuscript: *Non trovato.* But at the bottom of the page there is a note in the hand of G. Valentinelli, formerly librarian of the Marciana, which reads

Questo codice XXII fu veduto a questi giorni in Torino, come me ne avverte il bibliotecario del Duca di Genova in Torino. Venezia 12 aprile 1865.

Whether it was seen in the library of the Duke or not is not recorded, nor is there any explanation of how it got to Turin. But there is every likelihood that it was stolen from the Marciana, or from the Duke's library later, since the top of page one has been snipped by a scissors, or some similar instrument, and it is probable that the cut was made to remove the library's stamp.

(5) In 1913 our manuscript was bought from a dealer, whose identity is unknown, by the father of Dr. George Rosenthal, now of California. How the Florentine dealer acquired it, we have no way of knowing. It passed from Dr. Rosenthal's hands into those of *L'Art Ancien* in Zurich and from that firm into the library of the Johns Hopkins University.

THE CONTENTS OF THE CODEX

An outline of the work as a whole is given in the Prologue. Following a tradition which appears to be Franciscan and is certainly Augustinian, Triviano takes as his Biblical authority for his main idea a text from *Wisdom,* "Thou hast ordered all things, O Lord, in number, weight, and measure." Under *number,* the author will discuss the great question of whether One—or Unity—is a number or that of which number is composed. By *weight,* he will mean magnitude. By *measure,* he will mean time, following Aristotle who says that time is the measure of motion. This accounts for the first three books. The fourth book, he says, will be devoted to the question of whether the world had a beginning in time or is eternal. The last two books will be an Hexaemeron. The Prologue ends with the customary profession of faith in Catholicism and the disavowal of any heretical or erroneous opinion which may have been unintentionally expressed.

BOOK ONE

The question of number is introduced as essential to an understanding of the nature of the continuum. The problem of the continuum is whether it is composed of infinitely divisible parts or of ultimates which are not further divisible. But before that question can be settled, the prior question of the nature of unity must be raised. And the basic problem of unity is whether One—or the monad—is actually a number or that of which number is composed. According to

[1] I owe this information to the kindness of my colleague, Dr. Edward Williamson, who transcribed it in Venice.

Aristotle, One was not a number. Trivisano is anxious to demonstrate that it is a number, for by a fusion of the meanings of *unitas*—the number One, the monad, the unit, the element—he hopes to show that points and instants are simply units with all the properties of the number One.

He begins then by differentiating in good Aristotelian fashion between actual and potential number. Actual number is that which can be named as odd or even, what we would call a cardinal number. Potential number cannot be named nor given *realiter,* for example, the square root of 15. A second distinction in numbers must be made between those which are *numerati,* as when we assign a number to external things; those which are *numerantes,* which themselves enumerate a set of things; those by which we count. This distinction is that of the function or uses which numbers have, but to Trivisano they correspond to the external object, the meaning of a symbol, and the "soul." A third distinction is imposed upon him by the philosophy of his time, the distinction between form and matter. The form of a number has to be considered apart from that which the number enumerates; one can speak of ten horses or ships or men, and the objects enumerated do not change the form of the decade. But when one speaks of number *materialiter,* one has to remember that certain matters cannot be enumerated, so that there appears to be a problem of what numbers can and what cannot be associated with certain subjects. As for unity, that can be spoken of in two ways, since both corporeal and incorporeal beings can be said to be units. Both are indivisible as far as their quantity is concerned, but the corporeal is distinguishable from other units by its "ultimate nature"; the incorporeal is neither divisible nor distinguishable. Trivisano then points out that since his interests is in *numerus numeratus* from the formal and not the material point of view and in corporeal unity, other considerations will be omitted.

He then moves on to list certain characteristics of such numbers in terms of which he will decide whether One is a number or not. These characteristics are commonplace. I shall simply list them since they illustrate Trivisano's method of argument. Numbers then are simple or prime, or composite; regular or irregular, the former of which has sides which are equal, the latter not;[2] long or linear, as Two, square or areal [*superficialis*], as Four; cubic or corporeal, as Eight. The first is made by "congregation," the second by "generation," the third by "production." Thus units aggregated in a single direction [*secundum longitudinem*] constitute a line; lines generate surfaces or areas; lines and surfaces produce bodies. Four corollaries follow: (1) every composite number is generating or generated or produced; (2) every linear number is regular; (3) every square number is areal and every cube corporeal; (4) every square number is both areal and regular and every cube corporeal and regular. But none of these statements are simply convertible. The other customary traits of numbers, evenness and oddness, and so on, given by Euclid in the *Definitions* introducing the seventh book of the *Elements,* he decides not to discuss, since they are sufficiently known to all *qui aliquantulum arithmetricam didicerunt.* He then sets down his thesis: Unity is a *numerus numeratus,* simple, the principle of all corporeal beings in itself, an indivisible minimum in the continuum, incapable of being less by quantity nor greater through rarity, and nevertheless distinguishable in spatial position.

He first proceeds to list his opponents beginning with Euclid who defines number as a multitude composed of units, Jordanus Nemorarius, "Algus," Algebra, whom he apparently thinks is a man not a subject, Boethius, Isidore of Seville, and Avicenna, all of whom repeat the usual formula that the unit is what composes number and therefore cannot itself be a number. Against such authorities he argues that since Unity has all the characteristics of number, it too must be a number, though a number of a unique type. The proofs that Unity is a number are perhaps not needed in a summary for modern readers, none of whom has any doubts about the matter, but it may be well to cite one proof for its historical interest. I give merely his demonstration that One is a prime number.

Every number, he says, according to the mathematicians, is either a prime or composite. A prime number is one which is measured by unity alone, as appears in the seventh book of Euclid [VII, def. 11]. But since any number numbers [or enumerates] itself, as all concede, and there is no number which is enumerated by unity alone, except unity, as known by inspection, therefore unity alone is a prime number. But since according to all mathematicians any prime number is linear, and unity is a prime number, as has been concluded, it follows that unity is a linear number. And consequently unity is not only a number but also a prime and linear number.

[2] Trivisano makes a fusion between numbers and simple geometrical figures, as will appear shortly in the summary.

But One can also be shown to be a square and areal, a cube and corporeal.

This, however, is only the beginning of a series of demonstrations of the extraordinary properties of the number One. It is not only a square, but the first of the squares, a cube, and the first of the cubes. It is also an odd number and hence masculine. It is furthermore a "perfect" number, for it is equal to all its parts, since it has parts only *in potentia* and not *in actu*. Here it is clear that Trivisano is defining "parts" as factors. It is also "progressive" since it can be added to numbers to form a continuous series and can be the first number in a progression. To summarize the proofs of the other properties of Unity would be impossible, for the proofs are so detailed that they would have to be quoted *in extenso* to sound plausible. We can, however, cite the conclusion of the First Book which gives one some idea both of the properties which this number is believed to possess and also of the use to which Trivisano will put his findings.

> From all these things it is obviously possible to affirm that Unity which alone among numbers has every perfection, since it is the center of all magnitudes which are odd and regular, for it is the first linear number and hence generating, the first square and hence generated, the first cube and hence produced, and therefore bears a resemblance to the primal creator. It has also the greatest conformity to the Trinity which is one in essence, three in persons. From Unity itself, as has been said, is composed all created corporeal nature. It is the first essence, though of three perfections, which shows and demonstrates as far as is possible the perfection of its Creator. Most great in other respects is the power of Unity by which all material created things are constituted and measured and seem to be distinguished from one another. For all material things are composed of an amalgamation of units and of numbers composed by such amalgamation,

Trivisano thus believes that he has not only established the thesis that One is a number and a number *sui generis* but that it is identical with the units out of which all nature is created. For, as we have said above, he takes such words as "square" and "cube" in both an arithmetical and a geometrical sense and the latter to him applies to the real physical world. Hence cubes are not merely a kind of number but also solid bodies. It is this fusion of meanings which makes it possible for him to construct his cosmology on a numerical or Pythagorean foundation. He thus appears as one of the early members of the school of physicists who maintained the possibilities of finding mathematical expressions of all physical laws.

BOOK II

The main problem of Book II is whether the continuum is infinitely divisible or not. Opinion on this question is stated to fall into two schools: on the negative side are Plato and Democritus and "some few moderns," on the affirmative, Aristotle and Algazel and some of their followers. Trivisano himself maintains that the continuum is composed of atomic parts, further indivisible. He will break up his exposition into three sections, in the first giving the reasons of Aristotle and Algazel, in the second those of Plato, Democritus, and himself, in the third replying to the arguments of his opponents. He proceeds immediately to Aristotle's reasons for believing the continuum to be infinitely divisible.

In the fifth and sixth books of Aristotle's *Physics,* it is maintained that continua are such things as those whose ultimates are one and undivided. But the ultimates of the indivisibles are not one. Therefore continua are not made up of indivisibles. Indivisibles lack ultimates since it is one thing to be ultimate and another to be that of which a thing is an ultimate. Therefore, if an indivisible had an ultimate part, it would be either divided or divisible. Aristotle's second reason is that if the continuum were composed of indivisibles, then either the whole would be in contact with the whole or a part with a part. But the indivisible does not touch a second part since it has no parts. Therefore, it must touch the whole. If then two indivisibles are in total contact, they will not have distinct places and consequently would not constitute anything bigger than themselves. The third reason is physical. If the continuum were composed of indivisibles, then the indivisible would be divided. But this implies a contradiction. Three suppositions underlie this proof. First, that at any time something may be moved more quickly or more slowly; second, that the quicker traverses more space in equal time than the slower, third that it is possible that the time measuring the motion of the slower is in the proportion of one and a half times the time measuring the motion of the faster and this is taken in respect to its magnitude.

> The faster can be moved through a certain magnitude in a time composed of six instants by the first and second supposition. Therefore the slower could cover

the same ground in a time composed of nine instants by the third supposition. Just as the total time is to the total magnitude, so the mean time is to the mean magnitude and contrariwise. But the swifter can traverse the mean magnitude in a time composed of three instants. Therefore the slower will traverse the mean of its magnitude or be moved in a time composed of four and a half instants and thus the indivisible will be divided.

Algazel's reasons are six in number. (1) Let there be three indivisibles composing a continuum of which one is between the two others. Then one indivisible on the extremes will touch the middle indivisible or one will be the same as the other or not. If it is the same, then one of the extreme indivisibles will penetrate the middle indivisible and thus the three indivisibles will be the same. And in the same way one can prove that a thousand indivisibles will fuse into one. If, however, one extreme touches the middle indivisible and the other does likewise, then that middle indivisible must have parts and the indivisible will be divided. (2) Let there be a magnitude composed of seven indivisibles and let there be two mobile indivisibles on the ends which begin to be moved at the same time with equal velocity until they meet. But they can only meet in the middle. Then one of them will cut the first part and the other the other and consequently the same middle indivisible will be divisible. (3) If the continuum were composed of indivisibles, it would follow either that two indivisibles moving in opposite directions with equal velocity would not be able to pass through each other or that the indivisible would be divided. (4) It would also follow that the diameter would be equal to the side. But this is impossible.

(5) Let a rod be placed in sunlight and let us imagine a line coming from the center of the sun passing through the end of the rod to the extremity of the shadow. When then the sun moves in the sky, the shadow moves too, and the extremity of the line touches the shadow. I then ask whether, when the center of the sun is moved by one indivisible, the extremity of said line is so moved or not. If it is moved, it either traverses a part of a point on earth, which is impossible, because a point has no parts, or it traverses a point. And if it does, then while the center of the sun moves one point in the sky, the extremity of the shadow will traverse an equal space on earth and equal points make equal magnitudes. Therefore, while the sun traverses a given space in the sky, the extremity of the shadow will traverse an equal space on earth, which is impossible. For the sun traverses thousands of thousands of miles while the shadow moves only the distance of a single hair. If now the extremity of the said line is not so moved in relation to the sun's motion, then there would be one line having two extremities in relation to the same part, that is, the first point from which it is moved and the second at which it has arrived. Which is false.

(6) Let there be described a circle about the center of a wheel. Then it is asked whether when the wheel is revolved through one indivisible the circle described by the revolution is described by the greater or by the lesser [i.e. by the center or the circumference]. If by the first, then there will be as many indivisibles in the little circle as in the big one; if by the second, then the indivisible will be divided.

To these arguments, all of which think of the indivisible as extended in space, are added two arguments of Scotus and one of Gregory of Rimini, which take the same for granted, as well as a half a dozen others which Trivisano adds for good measure. As they all are based on premises which are common to those which we have summarized or quoted, there is no need to repeat them here. They do illustrate the preoccupation which men of this time had with the application of geometry to solid objects or to physical questions, as well as the ingenuity with which they fabricated and attempted to solve the paradoxes which this subject entailed. It would be perhaps more profitable to consider the arguments by which it is demonstrated that the continuum is composed of indivisibles.

Though the doctrines of Plato and of Democritus agree, continues Trivisano, in maintaining that the continuum is composed of indivisibles, they differ in that Democritus believes the indivisibles to be corporeal, whereas Plato held that bodies were composed of surfaces, surfaces of lines, lines of points. There are six ways of proving that the continuum is composed of indivisibles: (1) the way of "essential dependence," (2) that of "virtual coherence," (3) that of "resolution," (4) that of "diminution" (*minoratio*), (5) that of "measure," (6) that of the motion of the continuum.

(1) Essential dependence implies an order. There can be no order without posteriority and priority. Hence just as there must be a first cause in the order of causes, so there must be parts if there is to be a whole. Similarly the continuum must be an arrangement of something and that something cannot logically be infinitely divisible.

(2) Every whole composed of an infinite number of parts, as the cubit is composed of two half-cubits, is

a magnitude infinite *in actu*. But no continuum is a magnitude infinite *in actu*. Therefore no continuum is a whole composed of an infinite number of parts. Nor consequently can it be divided nor be divisible into infinite magnitudes.

It does have a potentially infinite number of parts, but not an actually infinite number. The argument here rests on Trivisano's assumption that the component members of a continuum must be discrete, an assumption natural enough in his time.

(3) The argument from "resolution" depends on the assumption that the continuum has no "proper parts," i.e., there is no more reason to cut it here rather than there. In this way it differs from a unit of measure which can be resolved into smaller units, as the yard is resolved into feet, and feet into inches. The continuum can be divided potentially in almost any manner, there being no *a priori* rule determining the divisions. Their order is not that of priority and posteriority—in spite of the proof above from essential dependence—but of composition. A body, for instance, can be potentially black and white and indeed other colors indifferently, though actually it must be one or the other of the possibilities. Therefore it is held that the continuum, however divided, will be resolved into a finite number of component members, though in accordance with another principle of division the finite number may be larger or smaller. But whatever the principle of division, there will be indivisibles in that system of relation.

(4) Everything from whose essence something can be taken as from a whole, has that something as an essential part. But one can take an indivisible from the continuum as from a whole. Therefore the continuum has the indivisible as an essential part. Trivisano cites as an example of this two straight lines which cross each other. Do they or do they not touch in some part? They obviously do and that part is an indivisible point. And therefore that point is an essential part of the line and the line—a continuum—must be composed of indivisibles. Moreover, if the point were subtracted from the line, the line would be broken. It would then lose its essential quality. It is to be noted that Trivisano believes that the point of intersection of the lines is common to both lines.

(5) If the continuum were infinitely divisible, the whole world could be contained in one small cube like a die. For one could slice off the die a thousand thin slices which one could then lay end to end and slice them into another thousand and so on until the slices enclosed the world. This seems impossible to Trivisano.

(6) The argument from motion runs as follows. If a line can be moved, then the point which terminates the line must be moved. But everything which is moved changes its location. Therefore the point changes its location. But Aristotle maintains that the indivisible cannot be moved and uses the motion of a line to prove the impossibility of a continuum's being composed of indivisibles. Therefore Aristotle is wrong. This result is so shocking that Trivisano feels that he must expatiate at length upon it, bolstering his simple demonstration of the mobility of points with other proofs. These are omitted here since most of them employ the same presuppositions as those summarized or are of so compact a nature that they would require translation at length.

The purpose of the rest of Book II is not merely to prove that the continuum is composed of indivisibles, but that these indivisibles are instants of time as well as points of space and that these two can be assimilated to the concept of unity. In order to accomplish this purpose it is necessary to examine various puzzles involved in the contact of lines, the divisions of time, the motion of concentric circles, and the like. As the text shows these puzzles and apparent paradoxes were multiple and evidently commonplace of the period. Trivisano, though he examines them at length also points out that there are many more which he does not want to weary his readers with. If he can fuse the concept of the Unit with that of the point and the instant, it is clear that he can attribute to these latter entities the almost miraculous properties of the first. This book, therefore, is not only useful as a demonstration of the kind of arguments which were used in the fourteenth century to prove physical theorems—or if one prefer, metaphysical theorems—it is also a kind of anthology of the opinions which men of this time held about the spatial and temporal continua.

BOOK III

The question now arises of whether the world has always existed or whether it had a beginning in time. And if it had a beginning, when did it begin? And how did it arise? Was it made by motion and transmutation or without these by emanation? Did the Prime Mover produce it eternally? Such are the questions which will occupy Trivisano in the third book.

He divides the authorities on this subject into the following groups.

(1) Aristotle, Averroes, and their followers. These maintained that the world is eternal, never having been created nor produced from anything pre-existing.

(2) Avicenna and Algazel. These maintained that the world had no beginning in time but was eternally produced by God, not created.

(3) Moses and the Church, and Plato. The world was created by God *ex nihilo* or out of eternally pre-existing matter.

(4) Democritus and Leucippus. The world was formed out of pre-existing atoms, infinite in number. No single world now existing has existed from eternity, but there are infinite worlds and always will be.

(5) Anaxagoras, Empedocles, and Heraclitus. There is one world, but it has not existed from eternity. But there was motion in the cosmic matter before the world was made.

The common assumption of those who posit an eternal world is that nothing is made of nothing, since everything that is made must be made of matter. Trivisano then proceeds to set forth the views of the various ancient philosophers, following Aristotle, in order to illustrate this presupposition. He takes up first those who posited the pre-existence of one kind of matter and then those who posited that of several. This whole section of the book is a good example of what knowledge men of the fourteenth century had of ancient philosophical beliefs.

After a discussion of the various elements of the material world, the theories of the Pythagoreans, and those of Plato, needless to say, as expressed in the *Timaeus,* Trivisano restates the principle question of the book, whether the world has existed from eternity or not. The argument here is purely dialectical.

Either God could have made the world from eternity or He could not have. The second alternative is heretical and therefore we accept the first. And if He could always have made it, then either He always wished to do what He could have done or He did not always wish to do what He could do. If the former alternative is true, then He always produced the world from eternity, which is contrary to fact. If the second, then he changed from not wishing to wishing, which is contrary to faith since God is not mutable.

The Scriptures, the Fathers, and the Saints have always maintained that the world did have a beginning in time. The problem is to explain the possibility of this. Trivisano, therefore, sets forth in three sections the opinions of the various philosophers for the eternity of the world; then the reasons of the theologians against this thesis, then a refutation of the first. This refutation is built up in twenty-one arguments. The arguments and refutations are equally dialectical.

Thus it is argued that if time had a beginning, and the world with it, then there would have to be a moment of time at which time began. That moment would be the last moment of the time before time began and the first moment of time as well. Similar arguments would follow from the assumption of a last moment in time. Therefore, in order to avoid an infinite regress—and progress—we assert the eternity of time and consequently of the world. Such arguments were common to metaphysics until Kant developed his antimonies of the pure reason. Trivisano is alive to all the difficulties of belief in the eternity of the world and also to those inherent in creation. In order to avoid them he distinguishes between generation and creation, and correlatively between corruption and annihilation. Generation presupposes matter out of which or into which the generated thing is generated. But creation is a term applied to that whose inception requires no matter whatsoever. So corruption is applied to that which leaves something material behind it after it ceases to be, but annihilation is applied to that which leaves nothing whatever behind it. Thus God can be said to create the angels and not to generate them. Similarly He annihilates but does not corrupt the angels. Similarly to exist from eternity must be understood in two ways. First it is said of that which has been from all time and it is in this manner that faith holds the world to be eternal. Second it is said of that which has continuous duration whether temporal duration or not—what would probably be called in modern philosophy the "timeless." This distinction is applied to all apparently temporal terms, such as "at sometime," "prior," and the like. Thus it would be false to say that God was before the creation of the world, for that would imply that time existed before there was any time. But it would make sense to say that God was, though the world was not, for He possessed a kind of duration outside of time.

From the nature of God and creation, as well as from the nature of time and eternity, six corollaries are said to follow which contradict the position of Aristotle, that the world is eternal. These corollaries are (1) that it is possible that something proceed immediately from and be made by God without motion and transmutation; (2) it is

possible that something be made *de novo* without its maker undergoing mutation; (3) creation is neither motion nor mutation; (4) creation is not mutation but is the dependence of the caused on the cause by which it was instituted; (5) creation is without succession (i.e., is a *totum simul*); (6) it is a property *in quarto modo* of God to create. The fourth mode of creating is given later in the manuscript where Trivisano distinguishes four senses of the verb *to create*. They are (1) to produce (*producere*), (2) to make (*facere*), (3) to bring to pass (*promovere*), (4) to make something from nothing, which Trivisano says is the proper sense of *to create*. God did not create all things *in quarto modo,* for though He created the Heavens and the Earth, he made the other corporeal things out of pre-existing matter.

BOOK IV

The program of the Fourth Book centers upon the actual age of the world and the time of the year in which it was created. Trivisano carries out his program by citing authorities among the *doctores sacrae scripturae,* the ancient philosophers, the astrologers, and the *computisti.* Most of these authorities maintain that the world was created when the sun entered the Ram and at the time of the vernal equinox, though others disagree with them. Thus Grosseteste asserts that the world was created in the month of *Nisan,* that is April, an opinion based on *Exodus,* ch. 12. That the world and time began at the vernal equinox is, however, founded on the belief of Grosseteste that this is the

> most temperate of times and the time of generation and that the equinoctial day has the special privilege among other days that the sun in its diurnal circuit of the earth illumines the whole earth and leaves no part of the earth when it shines upon it, whereas on other natural days the sun leaves some part of the earth without illumination, for a whole day without light.

The autumnal equinox will not do, since at that time "the sun is farther away from us."

The authorities whom Trivisano quotes in support of this thesis are the following. They are listed here as an illustration of the writers upon whom he relied.

Julius Firmicus
Hermes Trismegistus
Grosseteste
Rabanus Maurus
Peter Comestor
Vincent of Beauvais
Isidore of Seville
Servius [?] on Vergil's *Georgics.*
Richard Swineshead
Volterus [Walter of Odynton ?]
Al Bitrogi
Jerome
Bede
Ambrose
Basil
Damascenus

Opposing these authorities are the following.

Leicester [?] who in his *Computo* maintains that the world was created at the time of the autumnal equinox; Dionysius, "the Arabs and Egyptians," according to Vincent of Beauvais, and the Romans, according to Bede.

Some, however, place the beginning of the world in October. Among these are Roger Bacon, following Josephus. Still others put it in the summer, among whom are Julius Firmicus, Macrobius, and Al Bitrogi.

Trivisano then cites the opinion of John of Eschenden, that no one really knows when the world was created and no one ever will know unless it be announced to him by revelation. Trivisano prefers to agree, however, with the opinion that the beginning of the world took place at the time of the vernal equinox, though he agrees that Vincent's reason for assigning it to the autumnal equinox is *fortissima.*

The next question that is discussed is that of the ages of the world. Most authorities agree on there having been six ages. They disagree, however, on the length of each age. The first age ran from the Creation to the Flood, the second from the Flood to the birth of Abraham, a period whose duration is also a matter of dispute. The third age runs to the reign of David, the fourth to the destruction of the Temple or the Babylonian captivity, the fifth to the birth of Christ. Trivisano then states the various calculations of the Fathers, the Rabbis, and the Astrologers, and concludes that there is no certainty either about the length of each age or of the age of the world. One would need a divine revelation before attempting to be precise. Let this much, he says, stand for what human knowledge has achieved.

BOOKS V AND VI

The remaining books, as we have said above, are an Hexaemeron in the form of a vision. The author, after the usual protestations of orthodoxy

and disavowals of any opinions contrary to the teachings of the Church, proceeds to relate how he was transported to "that region called by the astrologers *Arim,*" which later turns out to be really *Mira.* Here he meets with none other than Moses who relates the story of Creation as it proceeded from day to day. Moses, anticipating Josiah Royce's God, has a chronosynoptic view of history, and quotes the New Testament and even Aristotle when it suits his purpose. The value of the beginning of this Hexaemeron (Book V) to historians of ideas is again its gathering together of number-symbolism, and the supposed relation between arithmetic and geometry, eventuating in the attempt to elucidate the logical problem of the doctrine of the Trinity by playing upon the apparently paradoxical properties of cardinal numbers. The sixth book opens with an exegesis of the first verses of *Genesis.*

As a sample of his method, we cite his comment on the name *Deus.* "This name," says Moses,

> is given to the most eminent being for four reasons. For He is called God as if He were the Lord and this in Latin since he rules all. He is given the Hebrew name of Fear, for He should be feared by all. In the third place He is called in Greek, *Theos,* from *vision,* since He sees all. Fourth He is called *Theos* in Greek from *running,* because He runs through all things, not that He moves and changes, but that He bestows motion and change on all things.

This introduction leads into a theological discussion in which respect is paid to the Aristotelian argument for monotheism. The next question to be taken up is that of what creatures were first produced. The words, *heaven* and *earth,* raise problems of interpretation. Does *heaven* mean spiritual being and *earth* corporeal or are these words to be taken literally? What are the meanings of the words, *in the beginning* and *created?* Such are the problems which Moses attempts to answer. The answers are complicated since one has to consider not only all Biblical verses in which such words are used but also the writings of the Fathers and other ecclesiastical authorities. Then there are such puzzles as the shape of the heavens which God created. Was it spherical, hemispherical, square, triangular, hexagonal? Moses's answer is that it was circular, "because it is more perfect than any other figure." Moses also maintains that the circular heavens do not move. As for the earth, the element, earth, is spherical, but the Earth, as the habitation of mankind, is far from spherical, since its surface is marked by mountains and valleys, but nevertheless it tends towards sphericity in its shape. And this is proved by its shadow on the moon during an eclipse, as well as by the fact that the sun as it moves through the skies now illuminates one portion of the earth, now another. The perfect sphericity of the element, earth, is proved by its weight. "For if it is a simple element each of whose parts is heavy, it follows that each part seeks the centre and that consequently earth is perfectly spherical." The lack of perfect sphericity in the Earth is attributable, therefore, to its being a mixture of the element, earth, and other elements. The Earth finally is concentric with the sphere of the fixed stars.

The Earth does not however move. The hypothesis that it moves is made to save the appearance of motion in the heavens. But it cannot do so. For the sphere of the fixed stars itself moves and does not move in a regular fashion. Therefore the movement of the Earth would have to be irregular in order to explain the apparent movement of the sphere of the fixed stars. Nor could it revolve upon its own axis. For we see that bits of earth when removed from their natural position seek to regain it and when they are in their natural position, remain at rest. Were the Earth to revolve, it would have two contrary motions and that is in violation of natural law. And this is in accordance both with Aristotle and Sacred Scripture.

This suffices to give an idea of the technique of Moses's reasoning. What follows is a description of the work of the first three days and a fragment of the work of the fourth, at which point the treatise is broken off. Throughout Trivisano tries to reconcile the teachings of the Church, as he understands them, with those of natural science. He is convinced, as in the first four books, of the harmony between mathematics, physics, and theology. He accepts the traditional view of the chemical constitution of material objects, the doctrine of the four elements, as well as the usual views of the astrologers. If the Hexaemeron has been completed, it would perhaps have had its greatest value as a scientific *summa,* a compilation of the cosmological opinions of his times. As a source of material which is not usually found in modern libraries, it must be almost unique. It illustrates what knowledge a well educated man of university background would have known in Italy towards the end of the fourteenth century. Whether it contributes anything original to the

science of its time could be answered only by one more skilled than I in the literature of this period. But the very fact that it is not the exposition of a novel view is in itself of interest. For, if the opinion expressed about it in this paper is correct, it may be taken as a fair sample of learned opinion. Historians of fourteenth-century scientific thought, therefore, might do well to study it with this in mind, just as students of fifth-century thought would study Martianus Capella.