UNIT 4 PHILOSOPHY OF SCIENCE AND COSMOLOGY IN THE MIDDLE AGES

Contents

4.0 OBJECTIVES

In this unit I propose to deal with three aspects, viz. cosmology, the concept of time and the contribution of Roger Bacon (not to be confused with his more famous namesake Francis Bacon). This unit enables you to understand what happened in Europe after Aristotle. An appraisal of cosmology in middle ages demands that you not only exhibit hindsight, but also far-sightedness while you are traversing through middle ages. This is essential because this particular age exhibited an interplay of three major factors, viz. Aristotelianism, scholasticism and Arabic science which paved the way for Copernican thought after nearly fifteen centuries. Hence the main objective of this unit is to analayse the role played by first two factors in blocking further growth of knowledge for such a long duration. While this is the main theme of this unit, Roger Bacon finds place here because he had the foresight to argue for experimental science.

At the end of this unit you must be in a position to identify the change in the mindset of thinkers when compared with philosophers of antiquity.

4.1 INTRODUCTION

The Greek civilization till Aristotle's period is known as Hellenic civilization. With his death this civilization also came to an abrupt end. This was followed by Roman civilization. Astronomy was not a favoured discipline in Roman civilization. In the real sense of the word, therefore, there was no successor to Aristotle. The rise of Christianity heralded the beginning of a very long Medieval Age which became infamous for discouraging, sometimes prohibiting, any kind of intellectual activity. If Aristotle's death is reckoned as the beginning, then in a loose sense the length of Medieval Age stretches to nearly eighteen centuries. Though historians usually reckon the beginning of this Age from 5th century A.D. for our purpose, we can say, it begins from Aristotle's death only. Similarly, it may not be proper to regard the whole of Medieval Age as Dark Age, though we cannot say that there was systematic scientific enterprise in this age. There were only irregular intellectual activities. Hence it is very difficult to say that during this age the intellectual activities came to a standstill. Then in what sense and why do we call this age Dark Age? Answers to these questions constitute the main theme of this unit.

4.2 PTOLEMY'S SYSTEM

The length of Medieval Age or Dark Age referred above, actually, is the interval between Aristotle and Copernicus. The gap is huge in the sense that the west could produce only one Egyptian astronomer of significance, viz. Ptolemy, who lived in the second century A.D. (Galen who also lived in the same century does not engage our attention only because he was a physician). While Aristotle's age is Hellenic age, Ptolemy belongs to an age called Hellenistic age. There is a subtle difference between these two. While the former is essentially Greek producing what can be regarded as speculative sciences, the latter is the synthesis of several cultures which facilitated the application of mathematics to the study of universe. Secondly, and this is vital, Ptolemy's work is the result of a systematic mathematical treatment of the subject. As a result, observation took over cosmology from mere speculation. This accounts for the birth

of astronomy distinguishing itself from cosmology. Kuhn, therefore, rightly observed that Aristotle is the last great cosmologist of antiquity and Ptolemy is the last great astronomer of antiquity to which perhaps we can aptly add that Ptolemy is the primary source of modern astronomy. Shortly we will discover that these features not only distinguished Ptolemy from Aristotle in particular and Greek thinkers in general, but also laid the foundations for experimental sciences. Hence these differences proved to be vital for further growth of knowledge which took off several centuries later.

Despite prominent differences, Ptolemy inherited certain notions from Aristotle. Most important among them are as follows; dual motion in the universe, spherical shape heavens as well as the earth, the spherical motion of universe, and geo-centric theory which also implies immobility. However, the grounds on which Ptolemy made these assertions are truly significant. While the Greek philosophers, in general, indulged in speculation to arrive at results, Ptolemy resorted to observation and further maintained that at least some thinkers of antiquity also probably followed the same method. For the purpose of illustration let us consider the way in which Ptolemy, in his most important work Almagest, justified the spherical motion of the universe. 'For necessarily this point (here point means the earth because it is static) became the pole of heavenly sphere; and the stars nearer to it were those that spun in smaller circles and those farther away made greater circles in their revolutions…… and then they saw that those near ……. disappeared for a short time, and those farther away for a longer time….'. Further, according to him the earth is spherical 'sensibly'. The most interesting assertion he made about the earth is that it has the ratio of point to the heavens. There are two reasons. One reason is that in all parts of the earth the sizes and angular distances of the stars at the same time appear equal and alike. Secondly, everywhere the horizons cut the heavens into exactly half which would have been impossible had the 'magnitude of the earth with respect to its distance from the heavens been perceptible'.

Since Aristotle and Ptolemy together contributed to the creation of environment most fertile for Copernicus to develop his system, Ptolemy cannot be neglected. His work Almagest, a Greeko-Arabic word meaning 'The Greatest Compilation' is regarded as a path-breaking work. The Greeks called it the Megale Mathematike Syntaxis which means 'Great Mathematical Synthesis', which in Latin became Almagestum. It remained an authoritative source till

Copernicus entered the scene. Though, as mentioned earlier, in many important respects Ptolemy made progress over Aristotle's theory, on one cardinal count Ptolemy subscribed to traditional geocentric model, and consequently, its immobility. And this model, obviously, came with its religious baggage. His adherence to geo-centric theory to a great extent neutralized the progress which Ptolemy made over Aristotle. Not only Ptolemy held the view that the universe must be spherical because sphere is perfect, but also that the stars must move in circles. This is another important difference between Greek cosmology spearheaded by Aristotle on the one hand and Ptolemy on the other because in Greek tradition the stars are regarded as fixed. Another important difference deserves to be mentioned. The Greek tradition placed the sun just after the orbit of moon. But Ptolemy accepted subsequent arrangement which pushed the sun to the region between Venus and Mars and it became almost the official position throughout the Middle Age.

It is likely that the ancient Greeks grouped the sun and the moon together because these two planets were regarded as nonretrogressing planets since they were known for regular motion whereas the remaining five planets were grouped together because they were known for retrograde or irregular motion. This particular arrangement depended upon the observed velocity of the planets. Since the moon required only 27 (to be precise 1/3 has to be added to the number of days) days to complete the journey through the Zodiac in contrast with Saturn which required 29 years, velocity of a planet must be inversely proportional to its distance from the earth. This is precisely what the Greek tradition held. If it is acceptable then, its logical consequence is truly catastrophic. If the distance between the earth and any other body is zero then the velocity of that body must be infinite. The distance between the earth and itself is zero. Therefore the velocity of the earth cannot be zero. On the other hand, it must be infinite, which is surely absurd. It shows that mere increase in velocity is not adequate to complete the journey in comparison with, say, moon. However, an important fallout of this shift must be pointed out. The shifting of the orbit of the sun indicated better estimation of the distance of the sun from the earth. According to earlier calculation the sun would have been much closer to the earth. But now it is farther. However, it is a fact that before second century B.C. no attempt was made to calculate the distance between the earth and the sun. Better approximation of distance results in better approximation of all

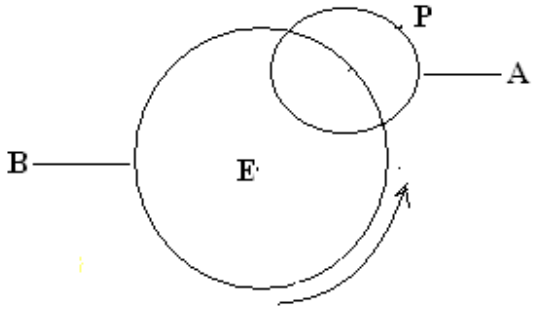
things related to the sun like its diameter, mass, temperature etc. which contributed to further growth of astronomy.

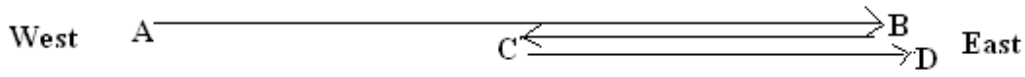
4.3 PLANETARY MOTION AND EPICYCLES

The greatest contribution of Ptolemy consists in his theory of planetary motion. Among seven planets the motion of the sun and moon did not pose any problem because their motion was always eastward. But it was not the case with the remaining planets. The remaining planets not only exhibited retrograde motion, but also they exhibited a certain pattern in irregularity. Irregularity meant only temporary reversal of path. Mercury reversed its path once in 116 days whereas Mars did so once in 780 days. The reversal pattern of the remaining three planets varied within this range. The astronomers thought that if irregularity is not random, then the path also must have been well-defined. This is the origin of the theory of epicycles. Indirectly, acceptance of epicycles weakened the hold of concentric circles or shells proposed by Aristotle.

Epicycle is a complex mathematical construction devoid of any physical reality unlike concentric spheres (if the claims of Aristotle with regard to the latter are acceptable). The origin of this theory is unknown. It is said that Apollonius was the first astronomer to introduce this hypothesis. In addition to this theory another theory also was suggested, viz. eccentric motion. However, the application of this concept is mainly associated with Hipparchus, a Greek astronomer, who lived in the second century B.C. because to a great extent he succeeded in explaining the retrograde motion of the planets. Later this theory assumed authority thanks to Ptolemy. Ptolemy's interpretation was so impressive that all subsequent astronomers in this age used this theory to construct their systems. An epicycle is defined by Hipparchus in the following manner; 'an epicycle is a circular path traced by a planet with its centre moving in a circle which has the earth as its centre'. Kuhn calls the circle traced by the moving centre of epicycle 'deferent'. Fig. 1 illustrates what Hipparchus and Kuhn meant.

EAST

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does not seem to think so. He, it seems, believes that Hipparchus retained the earth at the centre of the deferent. If we accept Kuhn's approach, then the distinction between equant and eccentric remains intact. Whether the earth is at the centre of the deferent or not, the concept of equant involved two aspects. The velocity of deferent was expected to be uniform not with regard to the centre of the earth but with regard to the position of equant. Secondly, when equant was taken as the reference point, the sun appeared to move slower between vernal equinox and autumn equinox and faster in the next segment. Therefore the first casualty is the violation of uniformity of motion which was totally unacceptable to Copernicus. As a matter of fact, he rejected neither epicycle theory nor eccentric theory. Apart from the violation of uniformity of motion, the hypothesis of equant was another source of problem in Ptolemaic system. Against this background, the shift from geo-centric theory to helio-centric theory in Copernicus proves to be vital, whereas other sources of differences centered on technicalities. Hence the former is more significant.

4.4 POST-PTOLEMAIC ERA

Though Ptolemy belongs to what historians regard as ancient age, his theory is a sort of bridge linking ancient and modern period.. In the introduction part of this unit a question was raised on the nature of Dark Age. Now we should search for answer to this question. Therefore we are concerned with what happened in this period.

Post-Ptolemaic era has its own peculiarities. Undoubtedly, in one sense there was no semblance of intellectual inactivity. The cessation of intellectual activity (whatever may be the sense) was promptly followed by loss of literature. Surely nothing worse can be imagined. However, in a sense altogether different there was something brewing. Paradoxically, after a certain time the ancient works were retrieved and scrupulously studied evaluated and interpreted though after the fall of Hellenic civilization Aristotle was nearly forgotten. In spite of activity at this level there was no attempt to construct any new theory in any field. Therefore there was no change in the world-view. This shows that any semblance of perceptible intellectual activity was within the conceptual framework of ancient period. In other words, there was no growth of knowledge. But

the Europeans succeeded in one respect. Though theories and problems remained the same, their perception underwent radical change. New dimensions were added to the theoretical framework. What made these achievements possible? There were several factors which contributed to this development.

The fall of the Roman Empire was followed by two new decisive forces; forces in different senses. The rise of Christianity and establishment of trade and commerce link with Arabs changed the very fabric of intellectual life forever. This happened in the 7th century and Ptolemy died in the 2nd century. The intervening period remained dormant. It was during this period that whatever Europe could lose, was lost. The Arabs discovered Aristotle and post-Aristotelians and therefore could restore ancient cosmology and astronomy mainly through translations from Greek to Arabic and subsequently from Arabic to Latin. Such translations stimulated interest in ancient learning giving birth to what is widely known as 'scholasticism'. Intellectual activity perceived in second sense materialized only after the Arab scholars discovered the lost literature.

Scholasticism suffered from infantile ailments. Between Aristotle's death and revival of ancient learning there were many interpretations. Aristotelians did not endorse all his arguments. They did effect changes. Ptolemy made several, if not total, structural changes. Coupled with these factors was translation of translation which was at worst misleading and at best inaccurate and incomplete. Situation was volatile enough to revolt against ancient learning which took some centuries to happen. Initially, the situation led to the belief that there were contradictions. Immediate concern was to resolve these apparent contradictions. Kuhn aptly sums up the trend in the following words. 'Where growth of knowledge should have been recorded, contradictions were noticed'. According to Kuhn this confusion arose because the whole of ancient learning was regarded as a sort of single body of knowledge. This attitude of critics, as well as of followers of Aristotle, is partly responsible for the degeneration of knowledge during the medieval period.

Cosmology and astronomy should have been considered either philosophical following the footsteps of Aristotle, or mathematical following Ptolemy. On the other hand, it acquired third dimension. It was viewed as esoteric. It did not happen overnight. The roots of theologization of

cosmology are in geocentric theory established by Aristotle and carried forward by Ptolemy. Ironically, mathematical aspects of Ptolemy's doctrine were thoroughly missed. The situation is very much akin to what happened in distant past with Pythagoras when Plato absorbed his mysticism despite the fact that Plato himself was influenced by mathematics. Returning to Medieval Age, it may be pointed out that the church started gaining stronghold from fourth century onwards. St. Augustine can be regarded as the first philosopher in post-Christ era. Though a philosopher of repute, neither logic nor science meant anything to him. He had only contempt for science, though he did have a certain concept of universe. In this case what he elaborated is, undoubtedly, creation theory in the strict sense of the term. Christianity, in fact, is the first religion (as a religion itself it is the first religion) to argue for creation out of nothing. Consequently, the world must have a beginning in time. But this entire description had only religious significance for him. That is the spirit with which St. Augustine carried further his argument. The only other element of philosophical significance in his doctrine is the concept of time. He maintained that time is linear, i.e., the flow of time is in one direction only. Again, he proposed this theory not because he wanted to develop a philosophical theory. Astrology is one offshoot of Aristotle's cosmology, which earned his wrath. St. Augustine's doctrine of time is the direct consequence of his opposition to astrology. The Church believed that astrology presupposes pre-determinism and hence is an obstacle to man's freedom to choose Christian values. Behind any philosophical doctrine of St. Augustine, a certain religious purpose can be easily discerned. Progress in any field is determined by the motive. If motive is oriented to philosophy, then only philosophy can progress. On the other hand, if the motive is religion-oriented, then, religion alone becomes popular and spreads far and wide. It was not just science which fell out of his favour. Anything unrelated to Christianity is irrelevant according to him. He argues that 'it is not necessary to probe into the nature of things, as was done by those whom the Greeks call physici…. it is enough for the Christian to believe that the only cause of all created things, whether heavenly or earthly, whether visible or invisible, is the goodness of the Creator, the true one God'.

The attitude of the Church was not hostile always. Therefore no sweeping remark can be made with regard to its stand. It oscillated from one end to the other for some centuries. For a little less than ten centuries Aristotle and Ptolemy were left out by the Church because it was widely

believed that their doctrines clashed with those of Christianity. In particular the Church was averse to the unreality of vacuum and timelessness of the universe because acceptance of these two theories would overthrow the Christian God. It shows that what mattered during this age was only the survival of Christianity. Perhaps St. Augustine had some role to play in this regard. If it is true, then it is truly ironical because Aristotle was almost resurrected by another equally famous Christian saint, St. Thomas Aquinas. This happened after thirteenth century when Christian Scripture, on the one hand and ancient wisdom in general and Aristotle in particular on the other hand, were reinterpreted to which the contribution of St. Aquinas is by no means meager. He maintained that the God created the universe out of nothing, a point of departure from Aristotle. Aquinas was fully aware of this crucial difference. In spite of this he indulged in a grand hermeneutic exercise because he was prudent enough to retain the potential source of support for Christianity. As a result of this exercise, the concept of central earth emerged as the single force which has the potential to reinforce the Biblical notion of universe. The Biblical notion of universe discovered sound support in Aristotelian doctrine. In the strict sense of the term this amounts to rediscovery only. Otherwise, the followers of the Church would have developed apathy to Aristotle at no point of time. If the concept of central earth is accepted, then it is very easy to establish that the heaven is above and the hell is below the earth. Further, the spherical shape and immobility of the earth reinforced the Biblical notion. This harmony was short-lived. The Church backtracked when rift arose between the doctrines of the Church and new theories proposed by science. This particular clash marked the beginning of Renaissance. This sort of vacillation points to two important conclusions. Conflict brings to the fore the determination to survive. All instances of conflict, as a matter of fact, generate the will to survive. Second, and most important conclusion, is that in the absence of conflict, the best neither comes out, nor does it survive if it comes out. Two instances which Kuhn has considered buttress these conclusions. Lactantius, a fourth century clergyman repudiated the idea of spherical earth because it was unimaginable that men could stand with their heads down. Kosmas, another clergyman of the sixth century regarded the earth as ‘rectangular plane footstool of the Lord. According to him not only the earth is flat, but also the universe is the flat substratum of the earth. Further, Kuhn adds that their doctrines were not granted official status by the Church though they were clergymen, propagating Biblical thought.

No other thinker, in this age, received as much of attention as Aristotle received. The focus and intensity of support and opposition remains always the same and one includes the other. Whenever the Church needed support it looked only to Aristotle as its savior. Whenever it perceived threat, the Church feared that only Aristotle fomented trouble. Even though Ptolemy subscribed to some vital doctrines formulated by Aristotle, the Church did not take cognizance of this fact. Therefore there must be something in Aristotle which is lacking in Ptolemy. Initially, it was thought that for religion science was a source of neither support nor threat. Hence it received only contempt. Ptolemy represented science. Perhaps on this ground the Church thought that Ptolemy could be sidelined. But this was not the case with Aristotle. Aristotle's cosmology is largely speculative with its roots in ancient mythology. Common ground for Aristotle and religion was easily noticed. Therefore for both good and bad the Church perhaps thought of only Aristotle.

Aristotelian system thrives on the assumption that the laws which govern the sublunary world do not hold good in superlunary world. Hence it was aptly called two-world argument. Both Aristotle and Ptolemy rejected the hypotheses proposed by two Pythagoreans viz. Heraclides and Ecphantus, fourth century B.C. cosmologists (in fact they were not the first cosmologists to suggest the motion of the earth, be in it any form. Earlier two Pythagoreans viz. Hicetas, and Philolaus, fifth century B.C. cosmologists, made the same suggestion.), who suggested that the diurnal motion of the stars might be the effect of the eastward rotation of the earth. It seems motion was the criterion of demarcation of terrestrial from celestial. Only then the distinction could be defended. Precisely on this count astronomers from sixteenth century onwards differed from ancient astronomers. The seeds of dissent were sown in the Medieval Age itself. Two developments are worth mentioning. The critics of Aristotle used two key issues which possessed the elements of Copernican system; the possibility of moving earth and the equation of motions of terrestrial and celestial bodies. Last two are studied under disciplines known as kinematics and dynamics respectively. Nicole Oresme thought that Heraclides might be preferable to Aristotle. He did not really believe that Heraclides was right and Aristotle was wrong. He only hinted that Heraclides' position was logically tenable. Ultimately, Oresme was proved right. Thus preamble was laid to Copernicus to establish his system.

Check Your Progress I

Note: a) Use the space provided for your answer

b) Check your answers with those provided at the end of the unit

1. Explain notions which are common to Ptolemy and Aristotle.

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4.5 ROGER BACON AND EXPERIMENTAL SCIENCE

A brief reference to a less known philosopher, Roger Bacon, who lived in the thirteenth century, is desirable for two reasons. First, he is a precursor to Francis Bacon and second, he himself being a saint, tried to bridge the gap between science and religion. He admits that there are two sources of knowledge; reason and experience. While reason is inadequate, experience is adequate. Therefore experimental science can have its roots in experience only. He extends the range of experience to mathematics also. He criticises Aristotle for appreciating reason at the cost of experience. A man of experience who knows the reason and cause by experience is perfect in wisdom. Only experiment helps us to acquire indubitable knowledge. There are seven levels of knowledge of which knowledge at first level is satisfied by experimental science and knowledge at all other levels acquires theological and ethical dimensions. In this way Bacon tried to achieve the fusion of science and religion at nascent stage itself. He says that experimental science is advantageous because only it has the ability to test the claims of other sciences while its own claims cannot be tested by any other science. His preoccupation with experimental science encouraged him to develop interest in alchemy, medicine optics etc. He is known to have claimed that the universe is five hundred times the distance between the earth and the moon. But for this statement Bacon does not seem to have said anything else connected with cosmology.

[Note: there is no such word as theologization. I have deliberately used this word to make one point clear. 'Theologization of cosmology' means that cosmology in its essence is not theological but only some thinkers projected cosmology within the framework of theological principles rightly or wrongly.

Kinematics is the study of motion which does not include any reference to force whereas dynamics is concerned with the study of force and its relation to motion.]

Check Your Progress II

Note: a) Use the space provided for your answer

b) Check your answers with those provided at the end of the unit

1. Examine the historical background of scholasticism and its nature.

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2. Give an account of St. Augustine's criticism of science.

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4.6 LET US SUM UP

After Aristotle's death the Greek civilization perished. Ptolemy accepted many aspects of Aristotle's cosmology. Ptolemy applied mathematics to cosmology. Aristotle's concentric circles were replaced by epicycles and deferents. This is a prominent difference between Aristotle and Ptolemy. Ptolemy is the last astronomer of repute who belonged to ancient age. From 4th century

onwards the Dark Age sets in when ancient literature was lost only to be discovered later by Arab scholars. After the Church became powerful, science was sidelined. St. Augustine disapproved Aristotle's cosmology because it supported astrology. St. Aquinas fused Aristotelianism and Christianity. Roger Bacon supported experimental science.

4.7 KEY WORDS

Epicycle: It is a mathematical construction employed by ancient Greek astronomers to explain irregular (retrograde) motion of planets. Since it is a circle change in the direction of motion which is natural to circular motion helped them to explain retrograde motion of planets.

Experimental Science: Science is said to be experimental when a scientist can control conditions at his will and bases his study on observation of phenomena which are under his control.

4.8 FURTHER READINGS AND REFERENCES

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4.9 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress I

1. Ptolemy inherited certain notions from Aristotle. Most important among them are as follows; dual motion in the universe, spherical shape of heavens as well as the earth, the spherical motion of universe, and geocentric theory which also implies immobility of the earth. However, the grounds on which Ptolemy made these assertions are truly significant. While the Greek philosophers indulged in speculation to arrive at results, Ptolemy resorted to observation and further maintained that the thinkers of antiquity also probably followed the same method. For the purpose of illustration let us consider the way in which Ptolemy, in his most important work Almagest, justified the spherical motion of the universe. 'For necessarily this point (here point means the earth because it is static) became the pole of heavenly sphere; and the stars nearer to it were those that spun in smaller circles and those farther away made greater circles in their revolutions…… and then they saw that those near ……. disappeared for a short time, and those farther away for a longer time….'. Further, according to him the earth is spherical 'sensibly'.

Check Your Progress II

1. There were several factors which contributed to this development. The fall of the Roman Empire was followed by two new decisive forces; forces in different senses. The rise of Christianity and establishment of trade and commerce link with Arabs changed the very fabric of intellectual life forever. This happened in the 7th century and Ptolemy died in the 2nd century. The intervening period remained dormant. It was during this period that whatever Europe could lose, was lost. The Arabs discovered Aristotle and post-Aristotelians and therefore could restore ancient cosmology and astronomy mainly through translations from Greek to Arabic and subsequently from Arabic to Latin. Such translations stimulated interest in ancient learning giving birth to what is widely known as 'scholasticism'. Intellectual activity perceived in second sense materialized only after the Arab scholars discovered the lost literature. Scholasticism suffered from infantile ailments. Between Aristotle's death and revival of ancient learning there were many interpretations. Aristotelians did not endorse all his arguments. They did effect changes.

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2. St. Augustine can be regarded as the first philosopher in post-Christ era. Though a philosopher of repute, neither logic nor science meant anything to him. He had only contempt for science, though he did have a certain concept of universe. In this case what he elaborated is, undoubtedly, creation theory in the strict sense of the term. Christianity, in fact, is the first religion (as a religion itself it is the first religion) to argue for creation out of nothing. Consequently, the world must have a beginning in time. But this entire description had only religious significance for him. That is the spirit with which St. Augustine carried further his argument. The only other element of philosophical significance in his doctrine is the concept of time. He maintained that time is linear, i.e., which means that the flow of time is in one direction only. Again, he proposed this theory not because he wanted to develop a philosophical theory. Astrology is one offshoot of Aristotle's cosmology, which earned his wrath. St. Augustine's doctrine of time is the direct consequence of his opposition to astrology. The Church believed that astrology presupposes pre-determinism and hence is an obstacle to man's freedom to choose Christian values. Behind any philosophical doctrine of St. Augustine, a certain religious purpose can be easily discerned. Progress in any field is determined by the motive. If motive is oriented to philosophy, then only philosophy can progress. On the other hand, if the motive is religion oriented, then, religion alone becomes popular and spreads far and wide. It was not just science which fell out of his favour. Anything unrelated to Christianity is irrelevant.