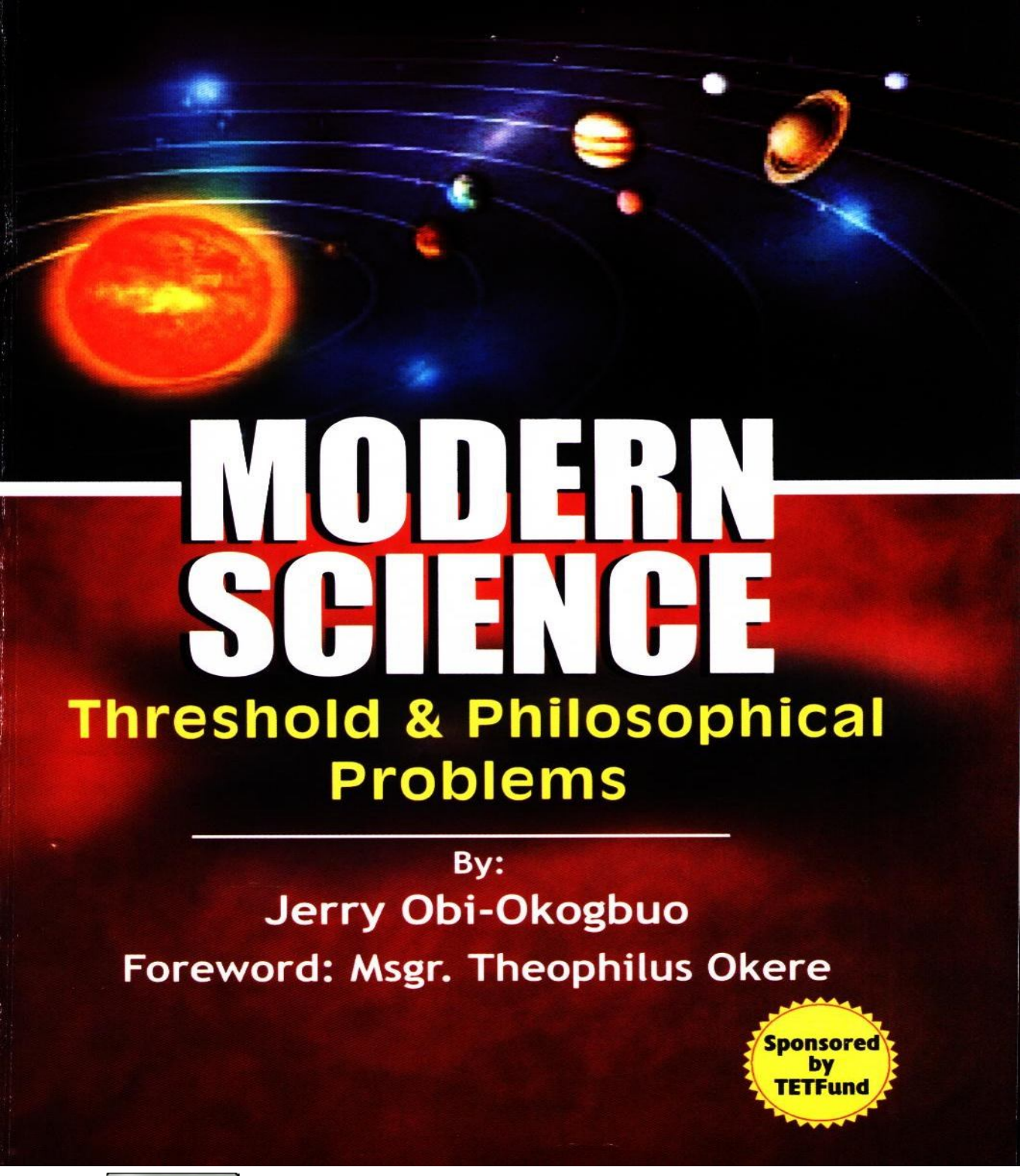

CHAPTER 6

SCIENCE IN THE MIDDLE AGES

PERIODIZATION:

There is historiographical controversy with regard to the exact duration of the period referred to as the Middle Ages.[1] But it is generally taken to be the long period of time, about a millennium, from the fall of the Western Roman Empire in 453 due to the barbarian invasions to the invention of printing in about 1450 or to the discovery of the New world in 1492. Roughly It is the period from the 5th to the 15th century A.D. On the bases of the turnout of events within this period it is normally divided into the High Middle Ages and the Late Middle Ages.

The High Middle Ages is the period extending from the barbarian invasions of the fifth century A. D. to the tenth century – the first intellectual re-awakening under Pope Sylvester II (999-1003). It corresponds with the period historically called the Dark Ages. While the Late Middle Ages, spans from the eleventh to the end of the fourteenth century. It begins with the Carolingian Renaissance in the 9th century, with John Scotus Erigena (810-877) as its first philosopher and William of Ockham (1280- 1349) as the last.

Generally speaking, the *weltanschauung* of the Middle Ages does not "...add up to a single, agreed-upon picture. It contained many things, including science and religion, mysticism and humanism, philosophy and idolatry, and a wide panorama of its own."[2] The popular opinion though is that "supernaturalism" was as dominant as "productive scientific" enterprise was non-existent. Accepted that supernaturalism was very high, it is too sweeping to say it was the only world-view, thereby denying the medieval period salient scientific contributions that impacted positively on the revolution in science in the modern period. Let us examine some of these salient scientific contributions in some details.

The High Middle Ages (THE DARK AGES):

The High Middle Ages, more popularly called the Dark Ages, is so called reference to the fact that during this period intellectual activities in science and

philosophy virtually came to a halt and the great literary works of classical Greek philosopher-scientists were almost lost. There was cultural darkness and intellectual dissolution. These were the dire consequences of the barbarian invasions and, to some extent the triumph of Christianity. The achievements of ancient Greece, their spirit of disinterested quest for the truth, which is the source-spring of science, all fell to the invasions of the barbarian. At this period too, Christianity had triumphed such that an overriding religious fervour took strong hold of every one and every institution. Thus whatever science there was intimately fused with religion, with the latter being the maiden and the former the handmaid. Francois Marie Arouet de Voltaire (1694-1778) aptly mirrowed the decadence of the period in the following lines: "At that time the human mind was possessed by a capricious medly of cunning and simplicity, of brutality and artifice, which was a strong characteristic of general decay and degeneracy.[3] Also Marques de Condorcet's anticlericalism painted similar picture of the bareness and inhospitality of the Dark Ages to science. He writes. "The triumph of Christianity was the signal for the complete decadence of philosophy and the sciences". At that time, according to him, "man's only achievements were theological day-dreaming and superstitious imposture." He goes on to say that the dissolution of power into the hands of the priests:

> gave rise to many absurdities; monks inventing ancient miracles or manufacturing new ones, feeding the ignorance and stupidity of the people with fables and prodigies, deluding them in order to despoil them; doctors of the church exhausting all their ingenuity in an effort to find new piece of nonsense with which to establish their faith or to out do their predecessors; priests compelling princes to burn any man who dared doubt one of their crimes, or who wavered for a moment from the course of blind obedience. [4]

Apparently the Dark Ages must have been a period of great intellectual stagnation and social trepidation, but Condorcet's anticlericalism went too far because it is on record that ancient science was kept alive and transmitted to modern world through many avenues one of which was by way of the translations made by priests, monks, and Christian scholars of the medieval monasteries. Nonetheless the inability to have productive scientific initiative in the Dark Ages was attributed to "failure to set a proper goal for the sciences, immoderate religious zeal, superstition, vanity, arrogance, and despair .. But the most

prominent cause was the lack of the true method of experience." These problems, as we shall see subsequently are not enough to say that the whole of medieval period was scientifically sterile; what is more accurate to say is that medieval science made no distinction between technique, theoretical magic and folk magic and as such needed anthropological imagination to understand it. It was also overshadowed by religion.

Through the Dark Ages, the great Greek works of science, of learning in general, were in part conserved and saved from total lost and eventually transmitted by the eastern monasteries by a few learned clerics, the doctors of the Latin and Greek churches, the Nestorians and other heretics. These made translations of the Greek works and wrote several manuals or encylopaedic compilations of them. Thus giving thought a theological tone. This trend was set by St. Augustine (354-430). He believed that God created nature for the use of man. He also believed that all natural processes had an ultimate spiritual purpose. There were also Beothius (+525) and has disciples Cassidorus and Isidore of Seville. In England, there was Bede the Venerable (+735). He spent a lot of time reckoning calendars to calculate the variable time of Easter. He also observed the link between the tides and the lunar cycle. There was the Irish Monk John Scotus Erigena (810-877) who knew Greek, a rarity at that time, and was also interested in astronomical theories. He adopted the opinions of Heraclides Ponticus who held the view that certain planets revolved around the sun which itself revolved round a stationary earth.

Through the Dark Ages, the universe was explained in terms of symbolism and allegory and this was generally accepted as science even through the Middle Ages. The Bestiaries, a blend of natural history and myth, based on the work of Physiologus, an anonymous writer of Alexandria in the second century, common at that time and in use throughout the Middle Ages illustrate this view. The bestiaries described, for instance, the albatross feeding its young on its blood as a symbol of the Eucharist. The stars were primarily taken to foretell and guide human events. Each sign of the zodiac governed some part of the body and each planet a bodily organ. The microcosm of man reflected the macrocosm of the universe. Astronomy, however, was not peculiar to medieval Europe. It had been practiced before then and continued even till the seventeenth century.

Though the Dark Ages was regarded as barren with regard to the development of natural philosophy, towards the close of the era, there was made a number of crafts, technical and technological innovations. The barbarians that

conquered Rome brought with them technics that improved the life of the people: improved methods of felt-making; the making of barrels and tubs; the cultivation of rye, oats, and hops; and above all, the heavy wheeled plough that provided the means for the development of the three field system on which the life of the medieval European manor was based. There was introduced too, at that time, the device of water-wheel for the grinding of corn which greatly saved human labour. In antiquity, human or animal driven querns were generally used for grinding corn. Mills became common in Europe during the Dark Ages. The crafts, technical and technological innovations provided the basis for a way of life materially superior to that of classical antiquity for the majority of men. There was also a comparatively high stability. Trade was booming smoothly and life was generally easier. Majority of men were saved the excruciating crude physical labour associated with antiquity. There was surplus of food over what the manors required for their subsistence. With crafts, commerce and wealth, towns and cities emerged about 11^{th} and 13^{th} centuries; these involved crusades, the building of the cathedrals, and the founding of universities. The craftsmen, the cathedral builders and students of the big towns and cities were fed and supported with the food surpluses from the regions, though communication was still poor at the time. Another major consequence of the technical innovations of the Dark Ages was the shifting of the centers of civilization from the Mediterranean to northern Europe.[5]

The Arabs: The Arabs constitute another major channel through which Greek and Hellenic science came to Christian Europe. In this context, the Arabs mean not only Arabs but all Arabic speaking Islamic peoples of Syria, Persia, and Arabia; the barbarian tribes who invaded Rome and carved out an empire for themselves stretching from the Pyrenees in the West to the borders of China in the east between A.D. 634 and 750. In actual fact, they were not entirely barbaric nomads before they started their conquests but marchents involved in sea-borne trade from Ujjain in India to Alexandria in Egypt, which they monopolized. Mohammed the Prophet, who through his doctrine inspired the conquest, was also known to have been a marchent himself.

The great period of Arab science extends from the seventh to the eleventh century with a center in the East, Baghdad; and another in the West, Cordoba in Spain. It was especially from the center in Spain that science was transmitted to the whole of Europe.

Islam played a vital role in the scientific development of the High Middle Ages. After the fall of the Roman Empire, the heritage of Greek and Hellenic science, in short science of antiquity was preserved and extended by the Arabs. This is made possible because Islamic culture readily assimilates the cultures of the countries it occupies. Also the Koran, the sacred Book of Islam, is not against the development of science. On the contrary, it encourages what it calls "the observation of the earth and sky so as to find in it the proof of their faith". The Prophet is also quoted as making statements which are in praise of science: "Seek knowledge from the cradle to the grave even as far as China" and: "He who goes in search of knowledge, God goes with him on the road to paradise". The Arabs translated into Arabia the great works of Greek and Hellenic philosophers and scientists which they inherited. In this regard, science is, over and above, knowledge of the religious laws but in Islam, this knowledge is not clearly separated from secular knowledge; medicine for instance.[6] Also, science trived with the Arabs because they were encouraged by the moral and material support of the authority, the rich, and the influential.

The Arabs translated into Arabic the great works of Greek and Hellenic philosopher-scientists, which they inherited. How much they added as their original creation we do not know because they are the main sources through which science of antiquity reached Europe; otherwise their main contribution is that of preservation and transmission. But it is imaginable that they must have contributed some original scientific ideas. They also learnt from other sources, from Persia, India, and China where they visited as marchents; and Mecca where they visited as pilgrims.

The encyclopedic nature of Arab scholars is something admirable. The greatest of them was at once philosopher, theologian, mathematician, astronomer and doctor. They usually begin with the translation into Arabic of great Greek writers like Aristotle, Euclid, Archimedes, Galen or Ptolemy. But they were not slavish translators for they also added commentaries. An outstanding example in this regard is Averroes (C.12 Century). He commented on all of Aristotle's works, for which he was called the "Commentator". Largely he remained faithful to the master but he added his thought where it best interprets that of the master. Ptolemy's astronomical work the *Almagest* was also interpreted and the errors in it were corrected.

Astronomy: Arab contribution to science was more in the field of astronomy: a science which they considered the queen of the sciences. They showed a natural

disposition to astronomy. They needed to determine accurately the time for prayers which according to the Koran is dependent on the position of the sun. There were many astronomical tables, some were of high quality, for instance, that of al-Battani (9thC), which was used for reference by great sixteenth and seventeenth centuries astronomers like Copernicus and Galileo. There was the solar table of Ibn Yûnus (10thC), used till the fourteenth century. Astronomical observations increased and spread, e.g., the Samarkand in Central Asia (1420). Also the instruments for astronomical observation: astrolobes, sextants, etc were improved.

Theoretically, the Arabs returned to the system of concentric spheres developed by Eudoxus, adopted by Aristotle and abandoned by Ptolemy. Averroes perfected it and Alpetragus, a Cordoba astronomer about the end of the twelfth century, took it up. Arab contribution to the other sciences was comparatively limited.

Mathematics: Progress in astronomy was intimately linked with progress in mathematics; and the Arabs contributed immensely in the development of mathematics. At the beginning of the ninth century, they adopted the decimal system – the figures we still use and call Arabic numerals today. They brought this numerical idea from India where they went for trade. Algebra and trigonometry, in their hands, became a distinct branch of mathematics.

Astrology: Though of Babylonian origin and attractive to Ptolemy, astrology was held in high esteem by the Moslem countries. With the Greeks and Arabs, astrology had an almost scientific status. The influence of the stars on human affairs, on the course of the seasons, and on the flow of the tides was not in doubt to them. Beginning from the ninth century, serious works on astrology, for instance, those of Abu Ma'shar (Albumaza) were noted. He was called "the master of the people of Islam concerning the influence of the stars". He was highly reputed and his reputation endured after him. At the end of the tenth century, Ibn Yûnus was both a famous astrologer and astronomer. Of all his predictions was that of his death which occurred on the exact day. Most cultivated, influential and wealthy, even Caliphs, encouraged astrology and surrounded themselves with specialists in casting horoscopes; but orthodox students of the Koran espy astrology, holding that God alone knows the future.

Alchamy: This was a mixture of science, technique and magic. Jâbir (10thC), was the most highly esteemed of the alchemists. There was great controversy between the mystics of Persian origin and the rationalists who endeavoured to remove magic from alchemy and to emphasize only the experimental and

classification aspects of it. Alchamy is the precursor of chemistry, a science that took a very long time to develop..

Physics: Alhazen (11thC), was the greatest scholar of physics in the Arab world of the Dark Ages. He wrote a remarkable treatise on optics, combining theory and practice. He contributed innovative theories of light and vision. To him is credited the concept that light rays come from the object to the eye; and also the concepts of spherical rays and secondary sources (re-discovered by Huygens six centuries later). He correctly explained the phenomenon of refraction by velocities propagated differently in different media, Kepler and Descartes in the seventeenth century were inspired by his findings. He also gave the first accurate description of the eye.

Medicine: Arab medicine was inspired by Galen who was one of the first translated authors by the Arabs. Avicenna (980-1037 A.D) was the most famous name in Arab medicine of the time. He was nicknamed the "Galen of Islam". He wrote the celebrated *Canon of Medicine*. But he was better a philosopher than a physician. Rhazes (10thC), one of Avicenna's predecessors, was a fervent rationalist who opposed all religious or scientific dogmatism. *Surgery* was also widely explored. The surgeon al-Nafis discovered the "lesser circulation" between the heart and the lungs. In this way was rectified Galen's error that the blood passed from one side of the heart to the other. The "lesser circulation" was rediscovered independently by Servet in 1553.

It becomes abundantly clear that the Arabs were not passive admirers and translators of the scientific authors of antiquity. The translation into Arabic and the interpretation of great Greek and Hellenic works were considered as starting points of their own investigations. The outstanding contrast between the two was that while the Greeks had a mainly intellectual contemplative approach to science, the Arabs cultivated a practical approach combining theory and practice. Their curiosities were matched with a desire for proof and careful observation. They appreciated accurate measurement and precise description – attitudes that favoured the progress of science.

The Late Middle Ages:

The Late Middle Ages was the period from the eleventh to the end of the fourteenth centure. Following the driving back of the Moors towards the sourth of the Iberian Peninsula by the Christian army, there was, between the 1100 and 1300, a kind of renaissance, a re-awakening flurry of keen intellects. Men started

turning back to nature again in a way never known but during the Hellenic science. This was sequel to the re-discovery of both Greek and Arabic sciences, especially Aristotle. The recovery of Aristole from the Arabs and his translation to Latin and transmission to Christian West had a profound effect on the schoolmen of the Cathedral Schools. For in Aristotle they saw a system beyond their previous experience. In the *Posterior Analytics,* they discovered Aristotle's Logic, his theory and method of science. In the *Physics* they discovered his basic concept of science. The effect of this recovery was the application of Aristotle's system and logic to theology.

The transmission of Greeco-Arabic science was mainly through Spain and to a lesser extent through Sicily. And scientific communication during the Middle Ages was by "speech and manuscript" – what has been called the medieval "scribal culture"; with its unfortunate predicament of having limited scientific community for its audience, corrupting or reducing and sometimes losing the content. Thatnotwithstanding, many manuscripts left Spain to be translated elsewhere especially at the Chartres and in England where schools of translation developed around scholars like Adelard of Bath. The first translations were made in the 2nd half of the 10thC at the monasteries of Catalonia by the Monk Gerbert d'Aurillac, the future Pope Sylvester II. Michael Scotus was another great translator. Among the works translated were commentaries on Aristotle by the Islamic philosopher, Averroes, and authors like Euclid, Archimedes and Galen were translated into Latin.

Scholasticism: This is the intellectual system of the medieval schools. Scholasticism was both a philosophy and an age mark on philosophy. It was concerned with logic and theology rather than with literature and secular studies (science). It was a coherent system of putting together traditional thought rather than pursuing genuine novel and original ideas. Scholasticism had a predilection to accept traditional authority. It was mostly a fusion of Christian theology and the philosophies of Plato and especially Aristotle. The schoolmen or doctors (as proponents of scholasticism were called) were content to study and criticize the science of ancient writers than search for novel truth in nature. It was a method of strict logical deduction in dialectical or disputational form in which theology subordinates philosophy.

These scholars of the Cathedral Schools grouped themselves together to form universities: Paris in 1160, Bologna about the same time. Oxford in 1167,

Cambridge in 1209, Padua in 1222, to name but the most outstanding universities. Scholars freely moved from one university to the other and freely indulged in speculations and writing treatises on natural philosophy but under the watchful guidance of the Church. The intellectual activities of these scholars were favoured by an amalgam of factors: they had one common language - Latin; they belonged to one unifying organization, the Roman Catholic Church; they were protected and encouraged by rulers of the time such as Emperor Fredrick II, King of Sicilies, and Alfonso X, King of Castille, who was nicknamed "the Wise". He encouraged astronomical studies. The "Alphonsine tables" which perfected the astronomical tables of the Arabs and used until the sixteenth century were ascribed to him.

The universities played the important role of being the link between ancient science and modern science. They were the agents through which the transmission of science from ancient to modern times took place. The translations from Arabic to Latin were done there. And all the major scientists of the seventeenth century scientific revolution were university educated and held career posts in the universities.

The universities – the 12/13th centuries medieval creation – started just as guild-like associations or corporate bodies of masters and students gathered together at the cathedral schools. Before the 13th century, the terms "university" and "guild" were used synonymously to refer also to crafts associations; but thereafter, the university was specifically restricted to a students' association.

The central problem of the High Middle Ages was how to reconcile faith and reason, theology and philosophy; or Augustine and Aristotle. So in the universities, philosophy (secular subjects) and theology were studied but theology was regarded as the "queen of the sciences" and thus received premium attention; while philosophy was regarded as the "handmaid" or "auxiliary" to theology. The staff of the universities was supplied by the religious Orders: the Franciscan and the Dominican. The Franciscan Order was founded in 1209 by the Italian St. Francis of Assisi; while the Dominican Order was founded in 1215 by the Spaniard St. Dominic of Galagora. Both Orders believed in service to mankind through teaching.

Grosseteste (+1253): was a Franciscan and founder of the Oxford school and later the Bishop of Lincoln. He had a thorough knowledge of Aristotle and Arab science. He did some great studies on the scientific method. He held that every hypothesis ought to be verified by observation. For him, mathematics is useful but

cannot demonstrate the efficient causes of phenomena. This efficient cause can only be deduced by studying the physical world itself. He shared with Alhazen the passion for optics and foresaw that by combining lenses and mirros it would be possible to observe distant and minute objects.

Roger Bacon (+1292): He was a Franciscan and student of Grosseteste. He inherited his master's boundless enthusiasm for science. The scholastic commentaries of Greeco-Arabic texts did not satisfy him; and so he advocated and heralded experimental science. He says: "There are two methods of investigation, through argument and through experiment. Argument does not suffice, but experiment does". He also says: "Reason proves nothing, everything hangs on experience." He shares his master's studies in optics which has the Alhazen inspiration. He is credited with the invention of gun-powder but this undoubtedly had Arab origin. He discovered the formular from the alchemist's secret book. Despite Bacon's seminal preference for experimental science, he still holds that all science rests on theology.

Albert the Great (+1280): He was a Dominican and a Great medieval figure. He admired Aristotle immensely and helped to make him known in many of the European universities where he taught. He was greatly erudite and as such did not slavishly subscribe to every opinion of his mentor: On the contrary he advanced his own views. He thus preferred Ptolemy's system of epicycles to Aristotle's system of concentric spheres. He doubted that the moon was a perfect sphere, and suspected that it had a relief system. He denied the eternity of the world. His original contribution, however, was in the field of natural sciences. He was the great naturalist of the Middle Ages. His description of minerals and plants was very precise. He excelled in the art of classification and suggested that new species could be produced through grafting.

Thomas Aquinas (1225-1274): He was a Dominican and student of Albert the Great. He stands out as the greatest theologian and philosopher of the Middle Ages and the most dominant product of the Late Middle Ages. The thirteenth century is regarded as "the greatest of all centuries" and as having "marked the end of an era" because it was the time that Aquinas achieved "true", "subtle", "elaborate," or "formidable" synthesis between Christian theology and Aristotelian science. He rejected aspects of Aristotle's opinion that could not be made to conform to Christian teaching. On the whole there were not many incompatibilities between

Aristotelianism and Christianity. Both agreed in purposeful nature but while that of Aristotle was immanent teleology, Christianity believed in the will of a personal God. Aquinas scholastic philosophy – Thomism, became orthodoxy in the Late Middle Ages and still is for Roman Catholics today. S.E. Stumpf beautifully outlines Aquinas' contribution in the following lines:

> The great achievement of St. Thomas Aquinas ...was that he brought together into a formidable synthesis the insights of classical philosophy and Christian theology. More specifically, Aquinas 'Christianized' the philosophy of Aristotle. Although his philosophical orientation was dominated by Aristotle, he was aware of the vast scope of thought produced by the ancients, the Christian fathers, and the earlier medieval writers, including the Arabian and Jewish writers.[7]

In actual fact, Aquinas synthesis was in three broad areas: science, philosophy and theology. In this synthesis he blended Christian dogma and Aristolelian philosophy in a way that respected natural knowledge. This synthesis is reflected in his hierarchy of the manifold of being. He discovered that being is the unity or the continuity thread from the lowest kind of material being to the highest of spiritual beings. And in this scheme man is at the center as the highest of material beings and the lowest of spiritual beings. Man was body and mind or spirit. The medieval synthesis of philosophy and theology signifies the dominant religious tone or orientation of the thirteenth century.

The Demolition of Aristotle: The demolition of Aristotle started in the 14thC. It started with disagreement to Aristotelian-Thomistic contribution to dynamics. Aquinas made some contributions to the field of dynamics, the study of the relation between force and motion. The problem of dynamics then was how to explain the movement of an arrow or a projectile. Aristotle had explained this by saying that a motive force accompanies the movement of a projectile. That is, the disturbed air by the projectile pushed it. This he called "forced movement" as opposed to natural movement. By natural movement the projectile or arrow should fall immediately to the ground once it leaves the string.

Jean Buridan (+1358) was a secular cleric and the Rector of the University of Paris. He applied the concept of "impetus" or "thrust" to advance the solution to this problem. He says: "it is by this impetus that the stone is moved after the one who threw it has ceased to move; but because of the resistance of the air which

pulls it in a contrary sense to that in which the impetus is pushing it, that impetus continually decreased."[8] According to him, the impetus of a body is proportional to the "quantity of matter" which it contains (today we talk of the mass).

Gradually we draw near to the modern concepts of quantity of motion and live force. In spite of its short-comings, this impetus physics departs significantly from Aristotelian dynamics. The idea of impetus must have been derived from the Indian for it is found in Arab science. It is also found in Albert the Great. In these, impetus was not precisely defined; we do not know whether it was a permanent quality of a body or a transitory form of the force applied after the initial impulse. Buridan applied the theory of impetus to the rotation of the celestial spheres. Aristotle had thought that the spheres were kept eternally in motion by divine intelligence. Thomas Aquinas replaced divine intelligence with simple angels. But Buridan holds that God delivers the initial impulse and then impetus takes over such that if there is no resistance, the rotation of the spheres would go on forever.

Nicolas Oresme (+1382) was a disciple of Buridan and the Bishop of Lisieux. He conceived the hypothesis of the earth turning on its own axis. This view was inconclusively considered by his master Buridan. Oresme concluded in the positive but in this he was returning to a view already held by Heracleides of Ponticus in the third century B.C. Oresme started suggesting the idea of the relativity of motion; and also doubted Aristotle's postulation of the earth at rest at the center of a revolving universe. But these were groppings, half-harzard and occasional oppositions against Aristotelianism since to doubt Aristotle's physics amounted to a certain audacity and a degree of risk.

The demolition of Aristotle and consequently scholasticism (Thomism) continued in the 14thC. Two main movements applied dialectical arguments to Aristotle's conception of science and gradually discredited it. One started in Oxford with the Franciscan Friars John Duns Scotus (1266-1308) and William of Ockham (1300-1349). The other started with the Latin Averroists in Paris in the 13thC.

Following the Arab commentators, the Latin Averroists stressed the determinism of Aristotle's philosophy. They maintained that all action in the universe is the result of a chain of necessary causes with the implication that freewill is not possessed either by men or God. In 1272 the Archbishop of Paris and Canterbury condemned this determinatism. This condemnation, the French historian Duhem holds, marks the beginning of modern science.

For toeing the line of the condemnation, the Averroists moved from Paris to Padua under the protection of the Republic of Venice from 1404. There they became anti-clerical and anti-papal. There too they discussed Aristotle independent of any theological framework. Aristotle's method of explaining empirical facts by deducing them from general principles obtained intuitively and hence beyond argument, was gradually modified into what was essentially the modern scientific method; namely, to begin from empirical observations, to derive from them some hypothesis of their fundamental causes, and then to test the hypothesis by finding whether the empirical observations could be deduced from it. In that way, the Latin Averrorists helped in the demolition of Aristotle and the development of modern science.

In the forefront of the demolition of Aristotle, however, is the Franciscan friars John Duns Scotus and William of Ockham. In actual fact, though they did not disagree with everything Aquinas said, they agreed with Aquinas on many matters; but if Aquinas great contribution was the synthesis of theology and philosophy, then each rendered a basic criticism against Aristotle's ultimate principle that tended to dissolve this synthesis. Against Aquinas doctrine that reason is supreme, Scotus argued that in God the Will is supreme. This view came to be known as voluntarism.

In voluntarism, the subject of theology – morality, is separated from the subject of philosophy – the empirical world. Faith is the approach in theology, reason is in philosophy. Thus voluntarism dissolves Aquinas synthesis between theology and philosophy. Against Aquinas "realism", the notion that universals as such have some form of independent existence, that is, the doctrine that asserts the reality of the universals, which when followed to its logical end is the doctrine of the subsistence form which means that the more universal a thing is the more real it is; pushed further to its conclusive end means that there is only one real being and that is God. Anything that is not universal is not real. To this Ockham replies: "universals are only words, mere names". This became known as nominalism or termism.

Nominalism is the view that only concrete individual things exist. Universal terms are words, 'noises', '*flatus vocis*', mere breath of air; they have no independent reality or existence. They are the names for the concepts particular things engender in the mind. Universals have meaning only as pointers. Man means the class of men; this man, that man, James, John, etc. Unless particular men exist man is meaningless. Individuals or particulars are the realities. They are

the referents or pointers. Ockhan says: "no universal is anything existing outside the mind of man." Aquinas had said almost the same thing: that universals are found in things, and are abstracted from things *post rem* (after our experience). But Aquinas accorded universals a metaphysical status when he said that they exist before individual things do as ideas in the mind of God, as universals *ante rem*. This latter point Ockham rejected, he also rejected the doctrine of divine ideas for the same reason Scotus did, in God the Will is supreme.

Ockham's view (nominalism) was genuinely empirical. The mind does not know anything beyond concrete individual things and their qualities. Thus nominalism renewed interest in explaining the character of nature, that is, it renewed interest in science. Thus, it severed the synthesis between philosophy and metaphysics, making philosophy something more like science. Theological and religious truths are not to be achieved by philosophy or science. Ockham's position amounts to something like the doctrine of double truth, enunciated by the Averroists. According to this doctrine, one kind of truth is available through science or philosophy and the other kind of truth available through revelation. The first truth is the product of reason and the other is a matter of faith. One kind of truth does not influence the other. The ultimate implication of the doctrine of double truth was that theological and philosophical truths were not only independent and not derivable from each other but that these different truths could even contradict each other.

Ockham's dissolution of Thomistic synthesis was influential and accentuated by the demolition of Aristotle. Consequently it had the effect of lowering learning in the whole of the fourteenth century. This lapse in learning was reinforced by the general social and economic disaster of the century. This came about in the form of the tragic Hundred Years Wars, the Great Schism, and the Black Death (the Bubonic Plague). All these gave the later part of the fourteenth century a general look of sterility. Philosophers and theologians were concerned more with freewill and conditions for salvation, a problem which brought about the Reformation. But with regard to the development of science, Ockham's nominalism acted as a catalyst such that the lapse in learning in the later fourteenth century was just twilight before dawn.

THE MEDIEVAL IDEAL OF SCIENCE

Medieval science was "on the whole somewhat deceptive". Just like the medieval world-outlook did not add-up to anything precisely, its science was

difficult to conceptualize. Among the reasons for this difficulty is the primitive medieval "scribal culture" of communication. This system of communication by "speech and manuscript" made the communication of the science of the time limited to a small audience of scientific community which in turn was inaccessible.

In the medieval era, science was more than ever so intimately fused with religion and other elements. There was a blend of symbolism (myth) and allegory. There was also astrology, theoretical magic and folk magic –all were accorded the status of science. Such a conception of science needed anthropological imagination to understand it. This is to say that there was an anthropological conception of science in the Middle Ages.

The task of science was perceived as to seek out the reason, meaning and purpose of things. These could be discovered by a careful analysis of the nature, essence and form of things. Thus the main concern of medieval science was with types and definitions of things. Ultimately then medieval science was primarily concerned with classification. That is, it was concerned with the "what" of a thing, not with the "how". It was concerned not with how a thing acts and reacts under different conditions. Today we can say that definition and classification clarify and enhance understanding even though they do not add to what is already known. But the medievalists did not see this as a short-coming since for them the content of knowledge was complete and finished, what it needed was just elaboration and analysis, and organization and classification sufficed to do that.

On the whole, the majority of the medieval/scholastic precursors of modern science subscribed to the Aristotelian ideal of science. Aristotle was colossal and omniscient in the Middle Ages. His works dominated scientific thought two thousand years after they had been written. They were encyclopaedic – embodying all the known science of his time – Aristotelianism was the fruition and epitome of ancient science.

The Aristotelian ideal of science was rationalistic and deductive. That is, it was a logical system, a rigorous demonstrative knowledge akin to the Euclidean (geometrical) model. According to this ideal, the principles or theories of physics were taken to be epistemologically prior to the facts and laws they purport to explain. The warrant for the principles or theories, such as that heavenly bodies must move in circles because circular motion was the perfect type of motion; was their intuitive and intrinsic character of self-evidence rather than their ability to account for the extrinsic empirical evidence.

Put in other words, Aristotelian methodology or scientific demonstration means to proceed from what is self-evident, what is better-known to what is lesser-known, what carried its own intrinsic warrant like Euclidean axiom or philosophical principle to what received its warrant from its being derived from the first principle. The geometrical axiom was not accepted because of the truth of the theorems derived from it, but rather the theorems were true because they were derivable from the axioms which were perceived intuitively as correct, self-evident and fundamentally indemonstrable.

In the medieval period, partly because of Roman tradition, the division between theory and practice was not quite so deep; the gap between theory and practice was increasingly closing up. In medicine, in agriculture, in mining, and in military technology, theory began to illuminate technique. Even in the universities, practical subjects were incorporated to a surprising degree in the general course requirements. Though the techniques available were not exceedingly in advance of those of Greece and Rome until after 1300, but they were no longer regarded as curiosities as in earlier times; now they are taken seriously as means to transform the temporal order. In spite of these, there still was no "theoria-techne interpenetration in the domain of physics. Part of the reason was the enormous authority of Aristotle in matters of method; the other part was the bookish character of nearly all university teaching and research. There was no laboratory work in the curricula; the final appeal was most often to an ancient work or a commentary on an ancient work. Direct appeal to observation, though not unknown, was overshadowed by the citing of authorities. The universities were simply not in living touch with the progressing technology, nor did it seem to them to be any of their business to aid in this progress. There was Roger Bacon harping on experimental science but he was like a lone beacon in a vast extensive plain and he also still holds that all science rests on theology. Consequently in the medieval ideal of science, observation (experimentation) had a more heuristic role of leading the mind to the principles, but once the principles were discovered, they no longer rested upon the observation which had occasioned them.

It becomes evidently clear that science so conceived as the medievalists did, a science which is a medley of religion, magic, myth, and allegory; a science which perceives knowledge as complete and finished, needing only to be defined, classified and organized, a science that is so rationalistic and deductive; a science that did not see the need for interpenetration between theory and practice could not get very far without being bugged down for such a science was static and not

equipped to deal with the eventualities of novelty which is the hallmark of modern science.

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