

SCIENTIFIC REVOLUTION: WHY IT OCCURRED IN EUROPE INSTEAD OF THE MUSLIM WORLD

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Abstract

This article seeks to explain the paradox that has baffled many historians of science, that is, how could the European Dark Ages easily give way to a "scientific revolution" in the 17th century? Indeed for several centuries or throughout the Middle Ages, a period ranging between 800 - 1500 C.E, Europe languished in the backyard of the history of learning. The European mind during this period was clouded with superstition as was reflected in the barbaric acts of burning witches and even killing scientists with impunity. Yet all of a sudden (barely after 100 years), in the 1600's a scientific revolution was not only set in motion but also broke out with amazing success. Various views have been given to explain this phenomenon, but one of them has been more often than not, down played; and this the contribution of the Muslim scientists during the Middle Ages. The gist of our argument in this brief article is that the Muslims' contribution to science and learning is one of the major elements that CANNOT be avoided if the 17th century scientific revolution that occurred in Europe is to be fairly and coherently expounded.

INTRODUCTION

The history of science concerns itself with what happened in the past with regard to the scientific discoveries as well as with the complex processes through which scientific discoveries and ideas developed from time to time. This concern renders it necessary therefore to also look into the behaviour of particular people that are thought to have contributed to the scientific phenomena over the ages. It is in this spirit that people of a particular civilization are given due credit for their contribution to the development of science which today has almost become the monopoly of western Europe and America. Many authors about the history of science contend that present day scientific phenomena has, through out the ages, been an absolute result of the western mind and effort at the exclusion of all other peoples. They are lured into this

belief due to the fact that the scientific revolution occurred in Western Europe. However, it is erroneous to attribute the entire bulwark of the history of science to the Europeans alone. Indeed other peoples and civilizations like the Greek, Chinese, Indians and above all Muslims did tremendously contribute whether directly or indirectly to the scientific phenomena.

Of the people whose contribution to science cannot be ignored at all, are the Muslims or the Islamic civilization for that matter. Their contribution was direct and so significant that one can confidently say that hadn't the Muslims done what they did in various fields of science, probably the scientific revolution wouldn't have broken out in Western Europe at the time it did. In the same manner one would plausibly argue that may be the scientific revolution would have broken out in the Muslim world hadn't particular events taken place to hinder the Muslims' scientific progress.

The task sought to be tackled in this paper therefore is to analyze the factors that hindered the occurrence of a scientific revolution in the Muslim world after having acquired a higher scientific tradition compared to other civilizations, and at the same time to explain the occurrence of the revolution in Western Europe instead. I propose the following procedure to go about this task. Firstly I will show, in a cursory manner; the scientific tradition in the Muslim world, revealing the high level achieved by Muslim scientists, then discuss the events that took place in the Muslim world showing their effects on the progress of science and lastly concern myself with the factors that facilitated the occurrence of the scientific revolution in Western Europe and in this process I will underscore the Islamic contribution to the revolution.

THE SCIENTIFIC PROGRESS IN THE MUSLIM WORLD

When many people write or speak of the Muslim world, they tend to confine it to the Arabs at exclusion of other Muslim peoples. They more often than not tend to make distinctions between Turks, Persians, Spaniards, Byzantines, and Arabs whom they depict as distinctively different people and therefore representing different civilizations.¹ Little do such people realize that the Islamic civilization did not take place in a vacuum. Indeed, it was an expanding civilization that through conquest and propagation brought in its fold various peoples or races that were subsequently assimilated in the Islamic tradition.² Bearing this in mind therefore, I shall take the Muslim world to be those people who professed the message of Islam with complete disregard of racial dichotomies, which are implied by some writers. The Muslim world to my mind was

¹ See Stephen F. Mason, *A History of the Sciences*, New York: Macmillan Publishing Company, 1962, chapter 9: Science and Technology in the Muslim World; 95-103.

² See Seyyed Hossein Nasr, *Science and Civilization in Islam*, Lahore: Suhail Academy, 1968, 29-32.

therefore constituted of peoples from Muslim Spain to Central Asia and down to the whole of North Africa (including the Maghreb) and to the Malay Archipelago in South East Asia.

The scientific tradition among the Muslims that is worth the appellation "Islamic," is traced from nowhere but from the holy Qur'ān. The holy book indeed invites believers to observe nature and reflect on it in numerous verses. This command to reflect on nature, prepared the Muslim mind to recognize and later assimilate all those scientific ideas that were prevalent from the advent of Islam onwards. Thus though much of the Islamic scientific tradition is evidently adopted from other civilizations, it is very important to take note of the Muslim minds readiness, for such adaptation, as being from nowhere but from Islam. This is actually in conformity with what H. A. R Gibb enunciated as laws for the adoption of foreign culture. He gave three 'laws' thus:

First law: cultural influences (not superficial adjuncts but genuinely assimilated elements) are always preceded by an already existing activity in the related fields and... it is this existing activity which creates the factor of attraction without which no creative assimilation can take place.

Second law: The borrowed elements conduce to the expanding vitality of the borrowing culture only in so far as they draw their nourishments from the activities which led to their borrowing in the first place. If they develop so luxuriantly as to substitute themselves or threaten to substitute themselves for the native spiritual forces, they become destructive and not constructive elements ... a living culture allows the borrowed elements to develop to the extent that they are adaptable to and blend with its native forces, but resist with all its power their ever-luxuriant growth.

Third law: A living culture disregards or rejects all elements in other cultures which reject with its own fundamental values, emotional attitudes or aesthetic criteria. Attempts may be made to graft them, but the grafts do not 'take' and simply die off.³

This is the spirit in which the Muslim World adopted scientific ideas and at the same time discarding those that were deemed unfit within the Islamic worldview. Through it, many scientific traditions were adopted and assimilated. The most significant such traditions that were absorbed by the Muslims were the Greek sciences.

The Muslims most readily absorbed Greek sciences together with their accompanying philosophy. Astronomy was one of the most ancient sciences among the Mus-

³ H. A. R Gibb, "The influence of Islamic Thought on Medieval Europe," in *Bulletin of the John Raylands Library* No. 38 (1955), 82-98 as cited by C.A. Qadir, *Philosophy and Science in the Muslim World*, London and New York: Routledge, 1988, 25.

lims. As early as 750 AD, the Umayyad caliph Harūn al-Rashīd had already established an observatory in Damascus where astronomical studies and experiments were carried out. Many Muslim astronomers such as Al-Farghani (850), Al-Battānī (858-929) and Thābit ibn Qurra (826-901) advanced Islamic cosmological views, theories and experiments. Al-Battānī is particularly credited for his discovery of more accurate astronomical theories than those of Ptolemy which were hitherto dominant. Al-Battānī obtained values for the obliquity of the ecliptic and the precession of the equinoxes which were by far more accurate than those of Ptolemy. He also discovered that the Sun's eccentricity was changing. Barely a century after these two, there came in Cairo, Ibn Yūnis (d. 1009) who gathered together the records of observations made in the previous two hundred years and prepared from them the Hakimite astronomical tables.⁴ Elsewhere in the Muslim world other astronomers were making more astronomical experiments. In Spain Al-Zarkali (1029-87) of Cordova drew up the Toledian astronomical tables in 1080; modifying the Ptolemaic scheme of heavens by suggesting an elliptical different for the epicycle of the planet mercury.⁵ Other experimental works were carried out by Ibn Bājjah of Saragossa (d. 1139), Abūbakar of Granada (d.1185) and al-Bitruji (d. ca 1200). Muslim advancement in astronomy was real significant and this is evident from the many observatories that were constructed through out the Muslim world.

Besides those early ones in Damascus and Baghdad, other famous ones were: One in Raqqā built by al-Battānī, the one at Shiraz by Abdul Raḥmān al-Sūfī, that in Hamdan, which was used by Ibn Sīnā, another one in Maragha built by Hulagu Khan in 1261 and used by Naṣr al-Dīn al-Tūsī. Others included that in Samarkhand built by Ulugh Beh where scientists like Qadizallah, Ali Qush and Ghiyāth al-Dīn al-Khashānī carried out several astronomical studies and experiments. The Ottoman Sultan Murād III also built an observatory in Istanbul for his court astronomer Taqīyy al-Dīn.⁶ In addition to these individual astronomers, was a group of the Brothers of Purity - *Ikhwān al-ṣafā'* who compiled a highly scientific work known as the *rasā'il ikhwān al-ṣafā'*. In this work they advanced many astronomical as well as other cosmological theories such as astrology, meteorology, geology and geography.⁷ These people whose actual identity is rather controversial lived around 950-1030 AD. They were a secretive group who deliberated on a wide range of issues both scientific and philosophical.

⁴ See Stephen F. Mason, *op cit.*, 99.

⁵ *Ibid.*, 100.

⁶ See C. A Qadir, *op cit.* 116.

⁷ See Seyyed Hossein Nasr, *An Introduction to Islamic Cosmological Doctrines*, London: Thames and Hudson, 1978, 25-104. Hossein Nasr gives a comprehensive analysis of the *Ikhwānī's Rasā'il* with commentaries. He reveals the highly scientific nature of this work and its roots in Islamic teachings.

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Closely related to astronomy as a field of science was mathematics. As a matter of fact most of the Astronomers in the Muslim world were great mathematicians as well. The likes of al-Khawārizmi, (d. 835) Ibn Abī Ubaida of Valencia, Maslama al-Majriti of al-Andalus, (d. 1007) and 'Umar al-Khayyām (1048-1132) were also astronomers. Indeed their contribution to mathematics as an exact science was unmatched during the medieval ages. For example Umar al-Khayyām is known to have perfected the Jalali calendar used in Persia to date and is believed to be more accurate than the Gregorian.⁸

Alchemy is another scientific field in which Muslim excelled. Khālīd b. Yazīd, a grand son of the first Umayyad caliph, Mu'awiya was the first alchemist of the world of Islam, followed by Jā'far Muḥammad al-Ṣādiq (d. 765). The greatest Muslim alchemist was Jā'bir b. Hayyān (d. 776) whose books consisted of more than 500 treatises mostly on chemistry and of which 40 still exist. C. I Figuirin had this to say about the works of Jā'bir:

It is impossible to disown that alchemy has contributed mostly to the creation and progress of modern physical science. Alchemists were the first to put the experimental method in practice ... Moreover by unifying a considerable number of facts and discoveries in the order of molecular actions of bodies, they have brought modern chemistry into being Prior to the eighth century C.E Geber (Jābir) put into practice the rules of that experimental school. The works of Geber; *The Sum of all Perfections and the Treatise on Furnaces*, contain an account of progress and operations which conform wholly to the methods, at this in chemical investigation.⁹

Al-Rāzī was yet another great alchemist whose work the secret of secrets contains very clear description of chemical process on topics such as, the smelting of metals, sublimation, preparations of caustic soda, Ammonia, sodium and ammonium sulphide, preparation of glycerin from olive oil etc.¹⁰ Al-Irāqī was yet another prominent alchemist. These figures and many others no doubt produced works that are so pivotal to modern chemistry, which is a core subject of science.

Physics was yet another flourishing science in the Muslim world during the medieval period that depicts the high scientific tradition of Muslims. Prominent works in this field were produced by people like Qutb al-Dīn al-Shirāzī, Ibn al-Haitham (Alhazen), al-Bīrūnī and al-Khāzini. Ibn al-Haitham has been considered the greatest student of optics between Ptolemy and Witelo. He made significant discoveries in the

⁸ Seyyed Hossein Nasr, *Science and Civilization in Islam*, 53.

⁹ See C.I. Figuerine as cited by C.A Qadir, *op cit.*, 120.

¹⁰ See Seyyed Hossein Nasr, *op.cit.*, 268-278.

study of motion such as the principle of inertia and transformed the study of optics into a new science. He made experiments to determine the rectilinear motion of light, the properties of the shadows, the use of lens, the camera obscura, that he studied mathematically for the first time and many other essential optical phenomena. In refraction, he applied the rectangle of velocities at the surface of refraction centuries before Newton and believed in the principle of "least time".¹¹ Al-Bīrūnī was a famous physicist who was known for his opposition to Aristotelian physics especially on motion and space which he attacked not only by an appeal to reason but also by use of observation.¹² Al-Bīrūnī is in fact believed to have left behind a tradition of physics that led to study in mechanics, hydrostatics and related branches. Muslim scientists like Ibn Bājjā followed al-Bīrūnī and developed the theory of "inclination" thereby founding the basis of another theory of impetus and the concept of momentum which were further elaborated by late medieval scientists in the West.

Natural philosophy no doubt too flourished among Muslims. People like Ibn Sīna, al-Fārābī, al-Kindī, al-Bīrūnī, Ibn Rushdī, Ibn Bājjā, al-Ghazzālī and others made great contributions to natural philosophy. While some of them ardently supported the Aristotelian natural philosophy by word and verse, as was the case with the peripatetics, others like Al-Ghazzālī took different positions and some times radical ones from those of Aristotle. It is these natural philosophers that are responsible for the translation of Greek philosophy into Arabic and its later transfer to the West. Their contribution to the Islamic scientific tradition was no less important than that of physicists, alchemists, mathematicians, astronomers or physicians. Indeed more often than not they combined all these disciplines in their personalities. Ibn Sīna and al-Ghazzālī were for instance great philosophers as well physicians and their works on medicine is as significant as their philosophical works.

Thus from the above synopsis of the Muslim scientific tradition, it is evident that Muslims were not so parochial in terms of scientific discoveries, experiments and theories. Indeed their tradition was comprehensive enough to sustain a scientific revolution. Why then did this kind of revolution not occur in their midst?

FACTORS THAT HINDERED SCIENTIFIC PROGRESS IN THE MUSLIM WORLD

Scholars have advanced various reasons to explain the failure of a scientific revolution to occur in the Muslim world. Both critics and apologetics have had a big share in this

¹¹ *Ibid.*, 128-129,

¹² See *ibid* for some questions, which he (al-Bīrūnī) asked Ibn Sīna on many theories expounded by the peripatetics. 133-138.

regard. Though it is not my intention to reproduce their arguments, one observation need be made of the critics' arguments, and that is, they accuse the nature of Islam as a religion to be responsible for this failure. Pervez Amrali Hoodbhoy perhaps is one of the most disparaging critics whose accusation can't go unrefuted. In his attempt to solicit reasons for the failure of a scientific revolution to occur in the Muslim world, he said of the philosophy of Islam thus,

A society oriented towards *fatalism** or one in which an *interventionist deity** forms part of the matrix of causal connections, is bound to produce less individuals inclined to probe the unknown with the tools of science.¹³

Else where Amrali insinuates that the nature of Islamic law has over the ages been rather hostile to important elements of capitalism, which he advances as precursors to scientific progress.¹⁴ This kind of explanation is by all means unfounded, a distortion of historical facts and therefore false in respect of both the Muslims and Islamic philosophy.

The apologetics on the other hand take to implicating Al-Ghazzālī in failing the scientific revolution in the Muslim world. They argue that Al-Ghazzālī's works on Asharite *kalām* and Sufism gave a final blow to the hitherto flourishing scientific tradition of Muslims. Contrary to their arguments however, Al-Ghazzālī was himself a scientist whose works have been appropriately described by Hossein Nasr thus:

The famous treatises of Al-Ghazzālī in the 5th/11th century; against rationalistic philosophers of his time mark the final triumph of intellection over independent ratiocination - a triumph that did not utterly destroy rationalistic philosophy, but did make it subordinate to gnosis. As a result of this defeat by Al-Ghazzālī and similar figures of the syllogistic and systematic Aristotelian philosophy in the 5th/ 11th century, the Islamic Gnostic tradition has been able to survive and to remain vital down to the present day, instead of being stifled as elsewhere, in an overly rationalistic atmosphere.¹⁵

If the claims of the critics and apologetics are refuted, where then lie the reasons to explain the sorry state of scientific phenomena in the Muslim world especially after

¹³ Pervez Amrali Hoodbhoy, *Muslims and Science: Religious Orthodoxy and the Struggle for Rationality*, Karachi: Vanguard Books, 1991, 145-146. *italics mine.

¹⁴ *Ibid.*, 155 Here Amrali's confusion seems to arise from the fact that scientific discoveries were expensive ventures which required an awful lot of funding of the scientists, the funding that was lacking among the Muslims at the time of the decline of science as compared to that available in Europe. This wealth is what he calls capitalism. Capitalism as an ideology did not have much direct connection with the scientific revolution as Amrali insinuates.

¹⁵ Seyyed Hossein Nasr, *Science and Civilization in Islam*, 27.

the 13th century? An interplay of external as well as internal factors provides the answer to the question.

Externally, two hostile invasions were experienced by the Muslim world. These were the Mongolians and the crusaders. The Mongolians are known to have been very barbaric, primitive warmongers who sacked cities and destroyed long established civilizations from China to Eastern Europe. This group of barbarians overran the Middle East and occupied it for half century (Ca.1218-1268) during which period they not only terrorized people but also were actively involved in bringing down important structures of cities some of which were of great scientific significance. David Nicolle estimates their damage thus:

The cultural of the Mongol invasion was already enormous in terms of cities libraries and schools destroyed and teachers and scholars killed or dispersed.... some scholars have even suggested that the rise of Western European civilization from a position of cultural and technological inferiority to world domination was in part due to devastation inflicted on the Muslim world by the Mongols, coming so close after the crusaders sack of Byzantium Constantinople in 1204.¹⁶

A further examination of the Mongol invasion indeed reveals the more destructive nature of their invasion than brutal ravaging of cities. They were a people from a nomadic life background. Wherever they moved they carried along with them big numbers of horses and ponies, which were not fed on fodder but on pasture. This in effect implied that the Mongols could not avoid the countryside of whichever city they conquered. Subsequently, they displaced settled populations, which were hitherto engaged in agriculture on which the cities, places of scientific work, depended. This kind of phenomena had the obvious consequences of disorienting harmonious living of entire communities that tasted the Mongolians savagery. Nicolle describes this feature of the Mongol invasion of the Muslim lands thus:

After capturing Baghdad, Hulegu took his army back to Azerbaijan in the far northwest of present day Iran. Here the broad steppe-like grasslands provided excellent pasture for Mongol ponies while the cities of Maragha and Tabriz served as administrative capitals. Hulegu's court remained essentially nomadic and the entire area acted as an enormous base camp for his predatory army, a function that Azerbaijan and Hamadan have served throughout history.¹⁷

¹⁶ David Nicolle, *The Mongol War Lords: Genghis Khan, Kublai Khan, Hulegu, Tamerlane* Dorset: Firebird Books Ltd., 1990, 110.

¹⁷ *Ibid.*, 118.

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Thus the Mongolian invasion along with the terror it unleashed on the Muslim peoples, by all means had to retard all forms of civilization including the scientific progress. Not only were centres of learning ravaged and scholars either killed or sent into disarray but also the general peaceful atmosphere necessary for scientific innovation was tremendously disturbed.

Similar effects were felt by the Muslim world on its invasion by the Crusaders. These were another group of 'warmongers' sanctioned by the Pope in the early 13th century allegedly to liberate Jerusalem from the Muslim control. Several crusades were launched stretching for a period of over two centuries (1095-129) AD. Like the Mongolians, they also plundered Muslim cities, killed and terrorized their dwellers thus disturbing the peaceful atmosphere conducive for scientific progress.

Internally, the most plausible explanation for scientific retardation in the Muslim world, was its leaders' failure to harness and co-ordinate the scientific disciplines. Right from the very beginning; Muslim philosophers and scientists are seen to have been on their own without being adequately supported by the Caliphs and Sultans. Caliph al-Ma'mūn's construction of the *Bayt al-Hikmah* (House of wisdom) around 200/815 to which a library and an observatory were joined, was a good beginning which however was never well sustained by subsequent Caliphs. Besides, it was more of a research centre than a teaching institution.¹⁸ Though more such centres were founded within the Muslim world such as the *Dār al-'Ilm* (House of knowledge) in Cairo (395/1005), the *Nizām al-Mulk* in Baghdad (459/1067) and the Granada Madrasah 750/1349), these institutions did not concentrate heavily on natural philosophy and the pure exact sciences. This resulted in the failure to institutionalize natural philosophy and science. The Muslim natural philosophers and scientists are therefore seen to be more on their own than a body of organized scientists. Those who studied natural philosophy did it privately and though they were entertained at the courts of the Caliphs, they were hardly encouraged by government policy to teach natural philosophy and science in public *Madāris*. Other scientists who did not gain access to courts were left to teach in their own private circles to which students were solely attached and from which they graduated with an *Ijāzah* (certificate) permitting them to teach the ideas of their Sheikh or *Ustadh*. This system of education had its own problems and limitations. To the Sheikh it limited him to his own ideas while to the students it confined them to the ideas of the Sheikh. A conducive atmosphere of discussion with fellow students and benefiting from other would-be readily available scholars

¹⁸ Some scholars have argued that the caliph's objective of establishing the *Bayt al-Hikmah* was more to have access to Greek sciences especially logic, which Muslims needed to defend the principles of Islam through logical arguments against the Jewish and the Christian attacks and hence the confining of *Bayt al-Hikmah* to a kind of research center for the theologians instead of turning it into an institution of formal learning. See Hossein Nasr, *op cit.*, 70.

was not created. Such an atmosphere would be availed if an academic institution, a University, were established. From it students would be exposed to different disciplines by different *Shuyūkh* in such a systematic manner that could set certain standards and procedures through which a learner would pass before graduating. It would be in such a set up that sciences would have been institutionalized in order to have a coordinated scientific inquiry that would bring about a scientific revolution.

Thus to my mind, the failure of a scientific revolution in the Muslim world internally was more methodological or organizational than theological that is, it is hardly the nature of Islam nor that of Muslims that failed the revolution, instead it was an organizational problem which was coupled with the external factors already discussed above. Who knows, had the Mongolians and Crusaders not ravaged the Muslim lands, the latter would have realized the need to put up more organized institutions to promote science education at a more comprehensive scale.

FACTORS THAT FACILITATED THE SCIENTIFIC DEVELOPMENTS IN EUROPE

The European scientific tradition no doubt owes a lot to the Muslim world. At a time when the Muslims produced great scientists, and when the scientific and intellectual traditions were flourishing in their midst, their counterparts, the Europeans, were languishing in the backyard of the history of learning. The European writers themselves refer to this period (ca. 900-1500AD) as the Dark Ages signifying Europe's intellectual and scientific backwardness. Thus the very first and foremost factor that facilitated the scientific progress of Europe is traceable from the Muslim civilization. This was the provision of scientific theories and ideas, which constituted the first paradigm in the development of science in Europe, and later culminated into the scientific revolution round about the 17th century. Edward Grant one of the contemporary scholars on the History of science does not only recognize this fact but acknowledges it as well. He beautifully argues thus:

A scientific revolution would not have occurred in Western Europe in the 17th century if the level of science and natural philosophy had remained what it was in the first half of the 12th century that is, just prior to the translation of Greco-Arabic science that was underway in the later half of the century. Without the translations, which transformed European intellectual life, and the numerous events that followed from them, the scientific revolution in the 17th century would have been impossible.¹⁹

Thus the translation of Greco-Arabic sciences and natural philosophy into Latin was an indispensable precondition for the emergence of the scientific tradition in Eu-

¹⁹ Edward Grant, *The Foundations of Modern Science in the Middle Ages: Their Religious and Intellectual Contexts*, Cambridge: Cambridge University Press, 1996, 170.

rope. The significance of this factor is underscored in no better words than those of Grant when he boldly states that:

Because of the importance of the translated works, the civilization of Islam must be allotted a considerable share of the glory for the Western achievement in science. Centuries before, Islamic scholars had translated a large part of Greek science into Arabic *and then had added much that was original** to form what is conveniently referred to as Greco-Arabic (or Greco-Islamic) science, at the core of which lay the works of, as well as the commentaries on, Aristotle. This large body of learning was subsequently transferred to the Western world. Although science in the west might have developed without benefit of this Greco-Arabic legacy, the advent of modern science would undoubtedly have been delayed by centuries, if not yet still lie in the future.²⁰

It is important to note Grant's acknowledgement of the Muslims' "adding much that was original" to the Greek ideas before transferring them to the West. A fact that many subjective Western scholars on the History of science have denied. Had they added nothing that was original, Muslims would have had no significant claim to make towards the present day scientific phenomena.

Edward Grant though is not alone in recognizing the tremendous contribution of Muslims to the European scientific tradition and learning. He was actually preceded by Goichon A. M. who, in an Encyclopaedia of Islam entry on "Ibn Sina", stated that:

The transmission of Greek science by the Arabs [read Muslims]²¹ into Latin produced the first renaissance in southern Europe which began in the 10th century in Sicily, flourished in the 12th century around Toledo and soon afterwards in France. The two principle works of Ibn Sina, the *Shifā'* and the *Qānūn* made him an undisputed master in medicine, natural sciences and philosophy. From the 12th century to the 16th century, the teaching and practice of medicine [in Europe] was based on him. The works of Abū Bakar Muhammad bin Zakariyyā al-Rāzī were also known and he was considered a better clinician; the *Qānūn* provided an irreplaceable didactic corpus for the *Kitāb al-Kulliyātī fi al-Tibb* of Ibn Rushd corresponded only with the first part of *Qānūn*. The latter was translated in its entirety between 1150 and 1187 by Gerard of Cremona, and, in all, eighty-seven translations

²⁰ *Ibid.*, 171-172. * Emphasis mine.

²¹ The Muslim Scientists are all referred to as Arabs apparently because of their use of the Arabic language in their works. But they were not really Arabs for a great many of them were Persians, Turks and even Spaniards.

of it were made some of which were only partial.²²

Having inherited the first scientific paradigm from the Muslims, the Westerners were then armed with the knowledge that they were to transform in various ways so as to host a scientific revolution. The most significant process of the transformation of this knowledge was in its institutionalization. Europeans formed the institution of university, whose activities from the medieval times to the present day are the foundations of modern science.

At the university, proper management of scientific knowledge as well as natural philosophy was witnessed. Masters and students were availed an indispensable opportunity not only transmit knowledge from one to the other, but also to make further inquiry into the realm of learning. Natural philosophy triumphed in the West as it was systematically permeated from great philosophical works to the students. The freedom enjoyed by the masters and students at the university, was a very significant element at this institution. Whereas the Masters were availed a chance to have students from a strong background, the students were nevertheless not confined nor compelled to depend on one Master. At the same time the students had a wide range of subjects from which they would seek specialization. Besides natural philosophy and logic, students would be exposed to exact sciences like arithmetic, geometry, music, and astronomy, which constituted the subjects of study for the baccalaureate and Master of Arts degrees.²³ These two levels, coupled with the specified amount of time a student had to spend at each level before graduation, are but indicators of how the learning process in the West was becoming more organized and sophisticated. Almost all students at the university were equally exposed to scientific learning. Thus a body responsible for the production and multiplication of future scientists, the university, was by all means set to facilitate and ensure scientific progress in this part of the world.

In addition to the translations and the university, a third factor for the progress of scientific tradition in Europe, was the emergence of a class of theologian-natural philosophers. These people's major role was the endorsing of natural philosophy as a significant area of study. They basically saved natural philosophy from the would-be wrath of the Church.²⁴ Compared to their counter parts in the Muslim world who were

²² Goichon A. M., "Ibn Sina", in *The Encyclopaedia of Islam*, New edition 10 vols. Leiden and London: E. J. Brill and Luzac & Co.. 1986, 3: 944.

²³ *Ibid.*, 172.

²⁴ Note that during the Middle Ages, the Church was the most powerful institution in Europe that more or less directed all the socio-political affairs of Europe. Were it to unleash its authority in opposition to a particular discipline, such a discipline would crumble. However the theologians' endorsement of natural philosophy made the subject acceptable to the Church at least in principle. Had theologians opposed natural philosophy out rightly, the spirit of scientific inquiry would have been annihilated all together.

antagonistic to natural philosophy, theologians in the West struck a compromise between natural philosophy and theology. No wonder the latter needed the like of Aristotle's philosophical ideas to defend un-intelligible biblical doctrines like the Trinity and the Eucharist. As a matter of fact the Western theologians' stake in natural philosophy explains the paradox of the flourishing of Aristotelian philosophy, with which the Church was not very comfortable, at the medieval university, which was at the same time under the patronage of the very same Church. This does not however mean that there was more freedom to the natural philosophers in the West than in the Islamic world. Indeed the presence of incidents like the 1277 condemnations and later persecutions of scientists like Galileo (1564-1642 AD) are manifest examples of the Church's time to time outbursts against science which sometimes swept aside the theologian-natural philosophers' stake in science. Having endorsed natural philosophy therefore, the theologians went ahead to facilitate its study at the university. In fact they made it a requirement for students intending to matriculate for a theology degree to have attained a high level of competence in natural philosophy.²⁵ The product of this scheme is clearly demonstrated by the emergence of renowned scientists who were at the same time theologians. Popular figures like Albertus Magnus, Robert Grosseteste, John Peckham, Theodoric of Freiberg, Thomas Brandwardine, Nicole Oresme and Henry of Langenstein bear witness to this fact.²⁶

Besides the above cardinal factors, other conditions in the west prevailed to support scientific activities generally. Significant among them was the generally peaceful atmosphere for which Europe was known prior to the 17th century. Political and social stability in many cases means mental stability as well, without which no intellectual progress can be expected. Western Europe was never touched by the likes of the Mongolian terror that was unleashed on the Muslim world, neither were the Christian Crusaders as violent in Europe as they were in the Muslim world. Closely related to this apparent peaceful environment in Europe was the economic prosperity. The European city-states were more economically sound than many of the Muslim Sultanates. Private enterprises prospered in Europe and a class of wealthy entrepreneurs was eminent.²⁷ These entrepreneurs availed substantial wealth for all kinds of adventures. The Europeans did not only set out to discover the world via the sea and land, a thing that facilitated the flow of new ideas and led to economic prosperity, but also ventured into scientific inquiry. Expensive experiments were sponsored and more learning was fi-

²⁵ *Ibid.*, 175.

²⁶ *Ibid.*

²⁷ Note that the presence of these entrepreneurs though commensurate with the availability of much capital, they are not however synonymous with capitalism as an ideology as implied by Hoodbouy above.

nanced. Indeed the funding of the university was partly successful due to this apparent affluence of the common Europeans.

Thus armed with all these favorable conditions, it is reasonable that scientific revolution occurred in Europe in the 17th century.

CONCLUSION

The occurrence of the scientific revolution in Europe in the 17th century is not a disputable historical fact. That notwithstanding however, one needs to put this important historical scientific phenomenon in its proper context, thus the recourse to several centuries' events and processes prior to its full recapitulation. As hinted earlier, it is not true to bluntly say that the scientific phenomena throughout the ages were a product of European efforts alone. Indeed other parts of the world, in this case the Muslim world, are significantly part and parcel of the matrix of scientific developments. Their contribution was as fundamental as was any other elements that combined to bring up the revolution. Failure of the revolution to occur in their midst was but one of the many accidents of history. The factors that have been given above to explain the scientific blossoming in Europe may not be taken as absolutely exclusive to Europe. After all only one scientific revolution occurred in time, thus denying us an opportunity of comparison. May be the role played by the university in Europe, for instance, may have been played by another different institution elsewhere! For sure the scientific revolution could as well have occurred in China or even India, but because it occurred in Europe alone, we are bound to believe that the events and the conduct of Europe's scientists is what led to the occurrence of the revolution.

The Muslim theologians' attitude towards natural philosophy should not be over emphasized as having blocked the scientific progress among the Muslims. To this point I respond by appeal to the above Gibb's laws for adoption of a foreign culture thus, "a living culture allows the borrowed elements to develop to the extent that they are adaptable and to blend with the native forces, but resist with all its power their over luxuriant growth, a living culture disregards or rejects all elements in other cultures which conflict with its own fundamental values, emotional attitudes or aesthetic criteria". This is exactly what the *mutakallimūn* did with Greek philosophy within the confines of the worldview of Islam.