Science and Islam

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ﷻ - subhanahu w a ta'ala
ﷺ - sallallahu 'alaihi w a sallam
AH - After Hijrah
CE - Christian Era

Contents

Science and Islam

"...I'll end by telling a story. There was once a civilization that was the greatest in the world.

It was able to create a continental super-state that stretched from ocean to ocean, and from northern climes to tropics and deserts. Within its dominion lived hundreds of millions of people, of different creeds and ethnic origins.

One of its languages became the universal language of much of the world, the bridge between the peoples of a hundred lands. Its armies were made up of people of many nationalities, and its military protection allowed a degree of peace and prosperity that had never been known. The reach of this civilization's commerce extended from Latin America to China, and everywhere in between.

And this civilization was driven more than anything, by invention. Its architects designed buildings that defied gravity. Its mathematicians created the algebra and algorithms that would enable the building of computers, and the creation of encryption. Its doctors examined the human body, and found new cures for disease. Its astronomers looked into the heavens, named the stars, and paved the way for space travel and exploration.

Its writers created thousands of stories. Stories of courage, romance and magic. Its poets wrote of love, when others before them were too steeped in fear to think of such things.

When other nations were afraid of ideas, this civilization thrived on them, and kept them alive. When censors threatened to wipe out knowledge from past civilizations, this civilization kept the knowledge alive, and passed it on to others.

While modern Western civilization shares many of these traits, the civilization I'm talking about was the Islamic world from the year 800 to 1600, which included the Ottoman Empire and the courts of Baghdad, Damascus and Cairo, and enlightened rulers like Suleiman the Magnificent.

Although we are often unaware of our indebtedness to this other civilization, its gifts are very much a part of our heritage. The technology industry would not exist without the contributions of Arab mathematicians. Sufi poet-philosophers

like Rumi challenged our notions of self and truth. Leaders like Suleiman contributed to our notions of tolerance and civic leadership.

And perhaps we can learn a lesson from his example: It was leadership based on meritocracy, not inheritance. It was leadership that harnessed the full capabilities of a very diverse population-that included Christianity, Islamic, and Jewish traditions.

This kind of enlightened leadership - leadership that nurtured culture, sustainability, diversity and courage - led to 800 years of invention and prosperity..."

Carly Fiorina, the CEO of Hewlett-Packard, 26 September 2001.

Islam

Its presence is felt in all walks of life, from international politics to religious and ideological circles to personal lifestyle. This is because Islam is a dynamic way of life based on a powerful intellectual doctrine. Islam does not establish itself in people by blind faith or imitation, but rather by an invitation to the human being to think deeply about his existence and his surroundings. That is why the Qur'an is constantly encouraging man to think, ponder and contemplate.

It calls man to use his intellect and reason to make vital judgments about the profound nature of this Universe. When we look to the world around us, we observe many phenomena that establish a definitive proof for the existence of the Creator. Islam challenges the human being to think about them and accept the truth regarding the existence of the One Creator.

We are constantly discovering more and more laws that make up this order. We utilize these laws for the satisfaction of our needs. However, many people have failed to address the fundamental issue: Who or what establishes these laws? Did they create the Universe that they govern or did the Universe create them so as to bring order to itself?

It is impossible that either of these is the case because the matter in the Universe is dependent on the laws that govern it, and the laws are a function of the matter. Therefore, there must be something independent of both matter and natural law that created them.

It is only the Creator, the only one who is unlimited, self-subsistent and eternal that is worthy of being worshipped.

The Creator in Islam is called Allah.

Introduction

The West has claimed for centuries that its scientific progress was a direct result of separating religion from the practical life of the people, in other words, separating the Church from the State. It is stated that religion[1] cannot deal with the man's affairs in the ever-changing world, and adopting it only stifles creativity and progress in all walks of life, including science and technology.

It is a fact that throughout the history of Europe, the Church engaged in a very harsh treatment of the people, especially the scientists and the thinkers who opposed the views of the Church. This stagnated scientific thought and as a result, religion was perceived as impractical, inflexible, and full of contradictions. Hence, it was found to be unsuitable for the progress of humanity.

The Europeans have indeed suffered greatly under the Church. However, can generalizations be made, based on the experience of Christianity in Europe, that progress can only be made through man-made legislation and that the Laws of the Creator are somewhat inadequate or defective?

This booklet will critically examine the argument that religion hinders man's progress and it will show that there is no contradiction between science and Islam. Furthermore, the booklet will highlight some of the scientific achievements of Muslims during the time when Islam was implemented in a comprehensive fashion.

The Dark Ages in Europe

The adoption of Christianity by the Roman Empire was not based on the truthfulness of Christianity or on its ability to deal with man's problems. Rather, it was adopted by Constantine in 325 Christian Era (CE) to simply preserve the empire by building a common mentality and loyalty among the citizens. Christianity offered blind loyalty to the secular emperors based on the understanding that the temporal authority and the spiritual authority can harmoniously co-exist.

This understanding came from the saying attributed to Jesus,

"Render unto Caesar what is Caesar's and unto God what is God's."

Despite this, Christianity could not preserve the empire, and the demise of the Romans bequeathed many Christian states in Europe where the Church was able to dominate.

The domination of the Church meant that all affairs of life had to conform to the dogma of the Church. This caused many problems because the Bible, which the Church used as its authoritative text, dealt with only very limited matters. It gave some specific rules related to the Jews in their worships and their foodstuffs. It gave general moral principles for Christians and set norms for their prayers and communal worship. Unlike the legislative sources of Islam the Bible does not give detailed guidance on economy, politics (domestic and international), judiciary, criminal punishments, the structure and functioning of government etc. The Quran informs us that the Christians and Jews had changed their books so the Bible does not represent a preserved text from the creator to man and it leaves a huge gap when it comes to human societal affairs. This gap was an area of constant conflict of interests between kings, feudal barons and priests. During Europe's dark ages it was the priests who dominated life and when they gave judgments even kings had to submit. Yet these judgments of priests were an arbitrary and inconsistent exercise of their authority owing to the lack of a comprehensive legislative text to base their rules upon, and this laid the seeds of direct confrontation between the society and the Church.

With the passage of time scientific discoveries were made that were at odds with the teachings of the Church. To preserve its authority, the Church took some harsh steps against the emergence of new ideas. Many scientists were branded as heretics, infidels and satans. In 1042 AH[2] / 1633 CE, Galileo was forced to renounce his belief and writings that supported the Copernican theory of heliocentrism that claimed the sun was the center of the universe. Instead, the Church adamantly maintained the flawed theory of geocentrism, which stated that the earth was the center of the universe.

Also, plenty of evidence exists indicating that hundreds of thousands of women who were alleged witches were burnt or drowned. The response to this oppression from the people, especially the scientists, thinkers, and the philosophers such as Voltaire and Rousseau, was equally strong. They began to highlight the contradictions of the Church and called for nothing less than the separation of the Church and the State. The struggle had begun.

Desperate measures were taken by the Church to deflect the criticism, frustration and anger that were vented by the people. These measures failed to halt the flames of change that had galvanized the masses. The Church realized that it could no longer stay in charge of the State without reforming itself. Thus, a period of Reformation commenced. However, the Reformation did not guarantee any bright future for the Church as the struggle became intensified between the 16th and the 17th century CE.

The eventual outcome of the struggle for power between the Church and the thinkers and philosophers was the separation of the Church and the State. This solution was a compromise that limited the authority of the Church to preserving the morals in society and conducting rituals, and left the administering of the worldly affairs to the State. The separation between the Church and the State through the compromise solution was completed by the 18th century CE, and formed the basis of Capitalism marking the beginning of the Enlightenment period that sparked the industrial revolution in Europe.

It is therefore clear that Europe scientifically stagnated under the arbitrary authority of the Christian Church.

Islam as an Ideology

In order to understand the contribution of Muslims to the advancement of various fields of sciences, it is necessary to explain Islam, as it was Islam that provided the driving force of change and research. It is the Islamic ideology that deserves the credit and not the individuals themselves.

The word 'Islam', in Arabic, linguistically means submission. As a term, 'Islam' refers to the Message that was revealed to Muhammad ﷺ by Allah, the One Creator, and a 'Muslim' is the one who believes in Allah, and accepts Muhammad ﷺ as the last and final Prophet and Messenger of Allah. Consequently, a Muslim believes in Islam in its entirety.

In sharp contrast to Christianity and Judaism, Islam is not merely a religion. Rather, Islam is a unique and comprehensive ideology that guides the life of the human being. The Islamic ideology, by the definition of an ideology, consists of both the 'Aqeedah (creed, doctrine) and Systems, to regulate the practical life of human beings.

The Islamic 'Aqeedah provides the correct and comprehensive answers to the fundamental questions regarding humanity's existence and that of the universe. It addresses the issue of the human being's purpose in life, and links it with what preceded life and what will come after it, thereby settling humanity's core problem and providing the basis for systems and rules to properly organize human affairs. This 'Aqeedah also provides the basis for a means to implement Islam in reality, thus transferring it from 'theory' to 'practice'. This means of implementing Islam is the State, which is distinguished from all other states as the Khilafah. It is an integral part of the ideology and distinguishes it from a philosophy, which provides hypothetical ideas but no means to implement them.

The Islamic Systems provide a comprehensive structure to govern the affairs of human beings. It correctly establishes:

1) *The relationship between the human being and his Creator*
2) *The personal affairs of individuals*
3) *The various relationships (social, political, economic, and international) that exist in the society*

Thus, Islam constitutes a Creed and Systems. What distinguishes Islam from the ideologies of Capitalism[3] and Communism is that Islam is built on the correct idea, whereas the others are founded on a shallow and unenlightened view of the life of the human being, and the world in which he exists.

Because Islam establishes the correct understanding of life and places humanity in the correct context, the systems and culture emanating from the Islamic creed would correctly address the human nature and provide the correct solutions. In this context, Islam is compatible with the human being. Islam does not ignore a human being's instincts or desires, but organizes them in the proper context, including the survival instinct that prompts man to seek material progress through the acquisition of science and technology.

Only the full implementation of Islam in a practical and systematic manner would ensure the proper organization of our natural desires, including the desire for technological progress. The implementation of the Islamic System is a must, but until this fact becomes a reality our instincts, needs, and natural desires will either remain subjected to oppression, ignored completely, or satisfied by corrupt means. Regardless of having individuals satisfying their instincts the correct way, the society as a whole would not.

Islam is an ideology that was delivered to the world. The spread of Islam is neither confined to time or place, nor dependent upon science and technology. Although technology has changed the living conditions of the people around the globe, the needs and instincts of humanity have not changed. Therefore, Islam, which came to organize our needs and instincts through its implementation upon society by the Khilafah State is applicable and valid for all time.

Science flourished under Islam

The notion that religion is at odds with scientific development is alien to Islam. History shows that most of the scientific developments by the Muslims were achieved under the rule of Islam, and not when it was forcefully removed from their lives. Even the history books written by non-Muslim Europeans testify to this fact, and if that does not suffice, then one can survey the origins of many words used in the West, like alcohol, cipher, sugar, algebra, admiral, alchemy, atlas, coffee, cotton and so on, to find that they are Arabic in origin.

Many of these words, which are mainly used in science, came from the Islamic State[4] - an indication that scientific culture was well developed.

Science flourished under Islam. It was not subject to any of the repression, perpetrated by the Church in the West, which caused the "dark ages" until the people threw of the stifling influence of the Church. Islamic thinkers clearly defined two areas of knowledge. Ibn Khaldun says in his "al-Muqaddimah," "the sciences ('uloom) are of two types: a natural type for man to arrive at through his own thinking, and a textual type which he takes from the one who originated it. The first type is the rational and philosophical sciences which he can seek through his own thought; and by his faculties he discovers its subjects and issues, the forms of their proofs and the aspects of their teaching, so that through discernment and study he identifies the correct from the incorrect in his capacity as a human being possessing the faculty of thought. The second is the textual and traditional sciences, which depend on the report coming from a shar'ai source. In this type the mind has no scope except to link the peripheral issues to the foundation (usool)." Ibn Khaldun also said, "The rational or natural sciences are common to all nations since man arrives at them through the natural disposition of his thought."

In the area of Islamic legislation Muslims cannot take from any source or reference except the sharia texts. The wahiy instructs and orders the Muslims to refer all of man's affairs to the wahiy.

The Muslims clearly understood that the rational sciences are left open to the mind of man. In the domain of pure science we can exercise our thinking and take from other peoples contributions in the technical and scientific field. For example, if a person wanted to design an automotive engine he would refer to all the past and current engine designs, regardless of who designed them, Muslims or non-Muslims. The pure science does not concern itself with one's point of view about life be it Capitalism, Buddhism, or Islam. The pure science was understood to be the same for all people.

Therefore, it is with this clear definition that the early Muslims progressed very fast in all fields of science known at the time and

pioneered in to the new fields.

Islam directs man to think

Islam is a system of life that originated from Allah, the Creator. Allah is the One who created man, life, and the universe and subjected man to the physical laws that He imposed on the universe. The Qur'an, as revealed to Muhammad (saw), invites man to contemplate the physical world in order to understand his reality correctly and thereby appreciate more the greatness of the Creator as he lives and rules by Islam.

The invitation to think can be found in many places of the Qu'ran. Islam does not limit man to think in purely religious or scientific or matters, as the priests of past and present do, but established for him thinking as a necessity for the whole of life. Islam invites all to think about man, life and the universe, so that man arrives at the correct answers to the greatest questions facing him about this life, what preceded it and what is to follow.

Thinking therefore is very much a part of Islam. For indeed, the belief in Islam comes through rational conviction and not the blind following of the previous generations. In this way man becomes a thinker from his first embracing of the Islamic belief. He further distinguishes his character by thought as he refuses to follow the immediate satisfaction of his instincts like the animals and the hedonistic followers of Western Capitalism. The Muslim seeks to understand the Islamic texts so as to constantly seek Allah's pleasure in the performance of all actions only in accordance with the guidance of Islam. He thus fills his mind with contemplation of the Quran and the Sunnah.

Glimpses of Achievement under Islamic Rule

The staggering contribution of Muslims to science and technology, as mentioned in this section, are meant only to serve as examples and should be understood as merely representative of the glorious services rendered by Muslim scientists to the overall development of science and technology.

Before Islam, Arabs had a rudimentary knowledge of history and geography. Their history was limited to the annals of the local tribes and territories. Islam as an ideology pushes individuals to think and acquire education. Muslims are ordered to interact with others to carry the Message of Islam to them. In order to achieve this, the Muslims are ordered to build their material capability. The Khaleefah[5] is responsible to utilize any means, within the limits of Islamic Law, to take care of the affairs of the people. Therefore, all of these factors help to initiate the technological achievements.

From the early days of Islam, the Muslims of all regions in general, and those of Arabia in particular, traveled extensively through plains, hills, rivers, oceans, forest and deserts in connections with Jihad[6], Hajj[7] and trade. In the course of their life they collected information on social, political, historical, geographical, economical, agricultural and other conditions of the land they visited or settled in.

As a consequence of the collection of such information, sciences such as history and geography became rich. During those days the travel was tedious and hazardous because there were no means of transportation except animals, and no regular roads existed, yet the Muslims traveled extensively through all kinds of terrain.

So far as the physical or experimental sciences are concerned, the pre-Islamic Arabs had some knowledge of them. With their keen sense of observation, they gathered information on animals like horses, camels and sheep and on the indigenous plants of their vast deserts. Some medical use of these plants was also known to them. The names mentioned in the pre-Islamic Arabic literature of various internal and external organs of the human and animal bodies suggest that their knowledge of anatomy was quite fair. The Arabs had some knowledge of astronomy and meteorology as well. They had some

information on the fixed stars, the movements of the planets and the patterns of weather. A number of arts and crafts such as horse breeding and camel rearing were also in existence among them.

In order to make the foreign scientific works easily understandable, it was necessary to undertake the selective translations of these scientific works into Arabic. Arabic, being a flexible and rich language, easily provided sufficient terminology for the new sciences. The objective was not just to translate but rather to build upon what was translated.

A number of academies were established in many places in the Muslim world to carry out the work of translation. During the rule of the 'Abbasi Khulafa'a (Caliphs), particularly al-Mansur and al-Ma'mun, extensive activity was shown in the preparation and translation of scientific works. Significant work was accomplished by the end of the 10th century. The translators belonged to different ethnic and religious groups. For instance, Naubakht was of Persian origin. Muhammad ibn Ibrahim al-Fazari was an Arab. Hunain ibn Ishaq was a Nestorian Christian from Hirah.

The Muslim scientists accepted the scientific conclusions of others subject to their experimental verification and also made new observations and experiments that lead to new discoveries. Muslim scientists used the practical approach to scientific problems with the abstract thought.

Muslim scientists recognized the physical or qualitative and the mathematical or quantitative aspects of science. They made qualitative as well as quantitative studies of numerous scientific problems. For instance, Ibn Khurdadhbeh determined the latitudes and longitudes of various places in the Muslim world. Al-Biruni ascertained the specific gravity of a number of substances.

The experiments in chemistry, physics and medicine were performed in the laboratories and those in pathology and surgery in the hospitals. Observatories were set up at various places in the Muslim world, such as Damascus, Baghdad, and Nishapur to perform astronomical observations.

Arrangements for the dissection of the corpses were made for the practical teaching of anatomy. The Khaleefah al-Mu'tasim supplied a physician with apes for this purpose. Practical demonstrations of surgical operations for the students were given in the hospitals.

Literacy had reached the highest standard among the Muslim people during the 11th and 12th century CE. The scientific spirit of that age is indicated by the optical work of Shihab al-Din al-Qirafi, a scholar of Islamic Law and judge of Cairo (d. 1285 CE), which dealt with fifty optical problems.

Under Islamic rule, scientists not only made original contributions to science but also applied their scientific discoveries in technological innovation. They observed the stars, and prepared star maps for navigational purposes. Ibn Yunus made use of pendulum for the measurement of time. Ibn Sina used air thermometers to measure air temperature. Paper, compass, gun, gunpowder, inorganic acids and alkaline bases are some of the most important examples of scientific and technological developments of Muslim scientists, which brought about an unprecedented revolution in human civilization.

Muslim scientists made algebra a permanent branch of mathematics. The word 'algebra' is derived from its original Arabic root Jabr. Muslim scientists also evolved plane and spherical trigonometry, and applied it to astronomy. They also separated astrology from astronomy, because a belief in the influence of stars on the fate of human beings is heresy in Islam. Astronomy was thus developed to the stage of a pure science after its purification from superstitious beliefs.

The numerous Arabic[8] words and scientific terms currently being used in European languages (see Appendix II for full list) are living monuments of Muslim contributions to modern science. In addition, the large number of books in the libraries of Asia and Europe, the museums of many countries, and the mosques and palaces built centuries ago also bear an eloquent testimony to this important phenomenon of world history.

Some examples of words derived from Arabic are: cipher and

chiffre (in English and French respectively), derived from the Arabic word sifr (meaning empty or nil), describing a number written at the right of another numeral to increase its value ten times; the word alkali in chemical terminology used for that particular substance which gives a salt when combined with an acid, is a modified form of the Arabic word al-qali; the French word escadre and the English word squadron for a section of armed forces, have been derived form the Arabic word 'askariyyah used in the same sense; and the word admiral is derived from amir al-rahl and there are many others.

In the process of translation, the names of a large number of Muslim scholars have also altered, deceiving readers into thinking that they are the names of non-Muslim Europeans. Some such names are: Abul Qasim al-Zahrawi (Albucasis), Muhammad ibn Jabir ibn Sinan al-Battani (Albetinius) and Abu 'Ali ibn Sina (Avicenna).

It is quite obvious that the spirit of inquiry created in the Muslims and the scientific method of investigation that they formulated resulted in the evolution of modern science.

Mathematics

Number Zero
Arabic Numbers
Algorithms
Algebra made into science
Al-Khwarizmi's work on Algebra
Spherical, Analytical & Plane Trigonometry
Determining roots of quadratic equation
Sine, Cosine tables
Cubic equations
Work of Banu Musa on Geometry

The achievements of Muslims in the field of mathematics are extremely remarkable. A regular study of this science, like all other sciences, was begun during the time of the second Abbasi Khaleefah, al-Mansur, in the second half of the 8th century CE. During this period the work on mathematics was exclusively accomplished by Muslims.

Some stimulus came from Indian and Greek works that were later translated into Arabic. During the 5th century AH /11th century CE nearly all of the original and creative work was done by Muslims, and even non-Muslims wrote all their mathematical works in Arabic. The Muslims used numbers including the zero for counting in contrast with writing the amounts in words or counting with the letters of the alphabet. Thus they made arithmetic simple and applicable to the problems of everyday life in connection with commerce and trade. The number zero holds great importance in arithmetic. Without the zero it is not possible to indicate the figure like tens, hundreds, etc.

The West learned the use of numerals from the Arabs, and therefore called them the Arabic numerals. The diffusion of the Arabic numeral in Christian Europe was very slow. The Christian mathematicians either used the old Roman numerals and the abacus, or used the Arabic numerals together with their old system. It was only in the 12th century that after learning from the Muslims the Western scholars were able to produce some literature on the number

system without columns and incorporating the zero. This system was named algorithms (or algorism) which was derived by the Latin writers from al-Khwarizmi (a native of Khwarizm region), a distinguished Muslim mathematicians, astronomer and geographer of the 9th century CE who flourished under the Khaleefah al-Ma'mun. His full name was Abu 'Abd Allah Muhammad ibn Musa al-Khwarizmi (d. 850 CE). His influence on mathematical thought exceeded that of any other writer of that period. He wrote an encyclopedic work dealing with arithmetic, geometry, music and astronomy.

Algebra was made into an exact science by the Muslims. Al-Khwarizmi named his book dealing with this subject as Kitab al-Jabr wal-Muqabalah (The Book of Restitution and Comparison). The word jabr means restitution. It is the adding of some thing to a given sum or multiplying it so that it becomes equal to another value. The word muqabalah means comparison and is applied in comparing two sides of an equation such as A+B = C. The word al-jabr (Algebra) was originally used for simple operations, like additions and multiplication, but later it evolved into an entire subject. In addition, the Muslims founded analytical geometry as well as plane and spherical trigonometry.

Al-Hajjaj ibn Yusuf, who flourished between 786 CE and 833 ACE in Baghdad, was the first to translate Euclid's Elements into Arabic. This work was twice translated, first under the Khaleefah Harun al-Rasheed and second under his son al-Ma'mun.

Abu Sa'id al-Darir al-Jurfani (d. 845 CE), who was a Muslim astronomer and mathematician, wrote a discourse on geometrical problems.

By the end of the 10th century CE, the number of mathematicians increased immensely Abu Kamil, who was one of the distinguished mathematicians of this period, perfected al-Khwarizmi's work on algebra. He determined and constructed both roots of quadratic equations. He made a special study of the pentagon and decagon with algebraic treatment, mentioned the multiplication and division of algebraic quantities as well, resolved systems of equations up to

five unknowns. His work was studied and greatly utilized by al-Karkhi and Leonardo of Pisa.

Abul-Wafa's contribution to the development of trigonometry is remarkable. He was the first to show the generality of the sine theorem relative to spherical triangles. He gave a new method of constructing sine tables, and calculated the value of sin 30° to eight decimal places.

Now we come to the mathematical work of 'Umar ibn Ibrahim al-Khayyam, who was one of the greatest Muslim mathematicians and astronomers of the Middle Ages. While al-Khwarizmi deals only with quadratics, al-Khayyam mostly discusses the cubic equations. He makes a remarkable classification of the equations, which are based on the complexity of the equation, i.e. on the number of different terms which they contain.

The 'Banu Musa' or 'Sons of Musa', wrote a series of important original studies. One title was done by Muhammad ibn Musa, which dealt with the measurement of the sphere, trisection of the angle, and determination of two mean proportionals to form a single division between two given quantities. His interest was not limited to geometry; he also wrote works on celestial mechanics, the atom, the origin of the Earth and an essay on the Ptolemaic universe. His brother Ahmad wrote a fundamental work on mechanics, while al-Hasan wrote a study of the geometrical properties of the ellipse. Al-Hasan was perhaps the most gifted geometrician of his time. He translated the first six books of Euclid's Elements and left the rest unfinished because he was able to work out the remaining propositions himself.

Another mathematician and geographer was al-Hasan al-Marakashi, who flourished until 1262 CE. He wrote various works on astronomy, which was put to practical use in astronomical instruments and methods. Also, Abul-Abbas Ahmad ibn Muhammad ibn 'Uthman al-Azdi, a very popular Muslim writes authored 74 works that dealt with mathematics and astronomy. One of his books, Talkhis amal al-Hisab (Summary of Arithmetical Operations) was studied for at least two centuries. It was highly admired by Ibn Khaldun, and a French

translation of it appeared in 1864 CE.

Physics and Technology

Force, Motion and Light
The balance
Al-Khurasani, the clock maker
Hydraulic apparatus
Elasticity of air
Hammam (steam bath)
Magnetic Needle
Guns and Cannons
Science of Optics
Research in spherical & parabolic mirrors
Research in angles of incidence & reflection

Muslim scientists studied the fundamental questions of physics deeply. For example Ibn Sina made profound studies of such phenomena as force, motion, light, heat, and vacuums to name a few. A great progress was made in theoretical and applied mechanics. Valuable work was done in the field of mechanics on the wheel, axle, lever pulley, inclined plane windmill, waterwheel, toothed wheel, and other mechanical devices.

The physicist and astronomer al-Khazini wrote a book on mechanics, hydrostatics and physics named Kitab Mizan aI-Hikmah (Book of the Balance of Wisdom) which is the most remarkable medieval work on these subjects. It gives a theory of the force of the attraction of the Earth (gravity), according to which the universal force is directed towards the center of the universe.

In another book on the balance al-Khazini stresses the need to remove, as far as possible, the influences of temperature variation during weighing. When al-Khazini's other studies are considered, he seems to be a precursor of Galileo.

Before al-Khazini, 'Umar al-Khayyam did the greatest work on the balance. Ibn Sina and al-Razi (d.924 CE) contributed to the theory of

the balance. Al-Razi made investigations on gravity by using the hydrostatic balance, than called al-Mizan al-Tabi'i (The Physical Balance).

Muhammad ibn 'Ali ibn Rustam al-Khurasani was a famous constructor of clocks, and as a result, he was called al-Sa'ati (the clock maker). Another Muslim mechanic of the 13th century was Abul-'Isa Ismail ibn Razzaz Badi al-Zaman al-Jazari. He wrote a dissertation on the knowledge of the geometrical mechanical contrivance that deals mainly with hydraulic apparatus like fountains. This important work is interesting from the technical point of view, and represents the best Arabic work on applied mechanics. Qaisar ibn Abu Qasim, a mathematician and astronomer (d. 1251 CE) made improvements on the waterwheels. Such improved types of water-wheels are still seen on the Orontes and are among the glories of Hama.

Abu Nasr al-Farabi refuted the existence of a vacuum. He wrote a remarkable essay on the elasticity of the air. It is an original piece of research.

The Muslims developed the techniques of bathing. They constructed the hot steam bath called Hammam (from the Arabic root hamm, meaning to heat).

Muslims were the first to apply the directive property of the magnetic needle in determining their direction while traveling on the sea.

The Muslims were also the first to invent guns and cannons and use explosives material in them. The purpose of this invention was to throw bullets at the enemy from a long distance. The Chinese used sodium nitrate only. But the penetrating power of explosives was discovered and used only by the Muslims. Historians generally write that the guns were first used in the war of Cressi. But from the writings of many Muslims, it is revealed that guns bad been used earlier.

In one of these writings there is a story that a ruler named Yaqub

besieged an African town of Medra in 1205 CE, by attacking the walls with the help of sounding guns and machines. From every machine there came out a number of showers of big stones and fire balls.

The statement given by Ibn Khaldun in his History of Berbers also proves the use of the guns at the time of war. He writes:

"Abu Yusuf the Sultan of Morocco besieged the city of Sijilmasa in 1273 CE. He installed the instruments for besieging in front of the city. These instruments consisted of Manjneeq, Uraweand Handam with which the bits of iron were thrown. These bits were filled in the box of Handam, and the explosives kept behind them were set on fire. Its effect was powerful."

Muslims developed the science of optics. Ibn al-Haitham made a remarkable contribution towards this science. Indeed modern optics began with him. He showed remarkable progress in experimental techniques. He made research on spherical and parabolic mirrors and dioptrics. He noticed that the relation between the angles of incidence and reflection does not remain constant. He gave a better description of the eye and vision. He tried to explain binocular vision, and gave a correct explanation of the apparent increase in the size of the sun and the moon near the horizon. Ibn Sina made a deep study of light. He observed that if light is emitted due to the ejection of some sort of particles by the luminous source, the speed of light must be finite. Al-Biruni noticed that the speed of light is immensely greater than that of the sound.

Astronomy

Need for Astronomical Science
Travel for Trade
Find direction of Makkah
Building Mosques
Star Maps
Astrolabes
Building of Observatories

Celestial Motions
Geodetic Measurements
Verification of Solar Year
Astronomical Instruments

The Arabs took a keen interest in the study of the heavens. They developed this interest because as the dwellers of the desert who usually traveled at night in connection with trade, war and migration from one place to another, they found the direction of their journey with the help of the stars. The clear sky of the desert gave them a chance of making precise observations. Thus there was some locally acquired knowledge of the fixed stars, the movements of the planets and the changes of the weather. After the advent of Islam, the Muslims had to determine the time of the prayers and the direction of the Ka'bah. For this Muslims who once flourished in trade all over the world of launched Jihad, had to travel on the land and the sea. As an aid to travel, navigation and meteorology, a by product of navigation, they needed star maps. The necessity of such maps also resulted in their interest in astronomy.

The regular study of astronomy and mathematics was begun at Baghdad in the second half of the 8th century during the time of the second Abbasi Khaleefah al-Mansur. The investigations on astronomy continued until the end of the 11th century. Nearly all of the original and creative work was done by Muslims. Astronomy reached its highest in the 13th and 14th centuries. In the 12th century, the Christians and Jews started the work of translation from Arabic into Latin and Hebrew, and began to conduct research in this field. But until the end of the 13th century CE, no mathematical and astronomical work comparable to that of the Muslims could be produced by the Christians or Jews.

The Muslim astronomers also prepared the star maps to preserve the old astronomical knowledge and to use them as aid to travel navigation and meteorology. Astronomer Ibrahim ibn Habib al-Fazari was the first Muslim who constructed astrolabes. He composed a poem on astrology, and compiled a Zij (calendar) according to the Arab method. He also wrote on the use of astrolabes and on the armillary spheres.

During the time of Khaleefah al-Ma'mun the important work of translation of Ptolemy's Almagest from Greek into Arabic was completed. Khaleefah al-Ma'mun (786-833 CE) built an observatory in Baghdad in his Bait al-Hikmah (House of Wisdom) and another in the plains of Tadmor (Palmyra). In these observatories the fundamental elements of the Almagest like the inclination of the ecliptic, the length of the solar year, and the precession of the equinoxes were verified. Observations on the celestial motions were carried out and geodetic measurements were made.

More original and improved work was done in the second half of the 10th century. The elaboration of trigonometry, which was considered to be a branch of astronomy at that time, was also continued. Great attention was paid to the construction of good astronomical instruments, especially to the spherical astrolabe which was newly introduced at that time. Hamid ibn 'Ali and Jabir ibn Sinan were famous makers of astrolabes.

Ibn Sinan's full name was 'Abd Allah Muhammad ibn Jabir ibn Sinan al-Battani (Albategnius, Albatenius in Latin). He is considered to be one of the greatest astronomers of Islam. He carried out astronomical observations of a wide range and with remarkable accuracy for about 41 years (871-9 18 CE). He determined many astronomical coefficients, like the precession 54.5" a year and the inclination of the ecliptic 23° 35', with great accuracy. He noticed an increase of 16° 47' in the longitude of the sun's apogee since Ptolemy's time.

This led to the discovery of the motion of the solar episodes and of slow variation in the equation of time. Al-Hattani proved the possibility of the annular eclipses of the sun. Al-Battani's astronomical work was translated into Latin and Spanish in the 12th and 13th centuries respectively. It exerted a great influence on the European scholars of the Middle Ages and Renaissance.

Chemistry

Definition of Organic and Inorganic Chemistry
Sulfur Mercury theory of metals
Calcination (extraction of metals from their ores)
Reduction (chemical treatment)
Discoveries of various acids Sulfuric & Nitric acids
Preparation of Drugs
Applied Chemistry
Paper

Chemistry deals with the composition and properties of substances and the changes of composition they undergo. It has been divided into Inorganic and Organic. The conception of this division in modem Chemistry came from al-Razi's classification of chemical substances into mineral, vegetable and animal.

Inorganic Chemistry, which deals with the preparation and properties of the elements and their compounds, originally arose from the study of minerals and metals. Organic chemistry, which deals with carbon compounds, developed through the investigation of animal and plant products.

A Greek philosopher, Empedocles, held the view that all the four elements, air, water, earth and fire, were the primal elements, and that the various substances were made by their intermixing. He regarded them to be distinct and unchangeable. Aristotle considered these elements to be changeable, i.e. one kind of matter could be changed into another kind.

Jabir ibn Hayyan (Geber), a great Muslim Chemist of the 8th century CE, modified the Aristotelian doctrine of the four elements, and presented the so called sulfur mercury theory of metals. According to this theory, metals duller essentially because of different proportions of sulfur and mercury in them. He also formulated the theory of geologic formation of metals. Unlike his Greek predecessors, he did not merely speculate, but performed experiments to reach certain conclusions. He recognized and stated the importance of experimentation in Chemistry. He combined the

theoretical knowledge of the Greeks and the practical knowledge of craftsmen, and made noteworthy advances both in the theory and practice of Chemistry.

Jabir's contribution to Chemistry is very great. He gave a scientific description of two principle operations of Chemistry. One of them is calcination, which is employed in the extraction of metals from their ores. The other is reduction that is employed in numerous chemical treatments. He improved upon the methods of evaporation, melting, distillation, sublimation and crystallization. These are the fundamental methods employed in the purification of chemical substances, enabling the chemist to study their properties and uses, and to prepare them. The process of distillation is particularly used for taking extracts of plant material.

The most important discovery made by Jabir was the preparation of sulfuric acid. The importance of this discovery can be realized by the fact that in this modern age the extent of the industrial progress of a country is mostly judged by the amount of sulfuric acid used in that country. Another important acid prepared by him was nitric acid, which he obtained by distilling a mixture of alum and copper sulfate. Then by dissolving ammonium chloride into this acid, he prepared aqua regia, which unlike acids, could dissolve gold in it.

Jabir classified chemical substances, on the basis of some distinctive features, into bodies (gold, silver, etc.) and souls (mercury, sulfur, etc.) to make the study of their properties easier.

In the same century Jabir's work was further advanced by al-Razi who wrote many chemical treatises, and described a number of chemical instruments. He applied his chemical knowledge for medical purposes, thus laying the foundation of Applied Chemistry.

Abu Mansur distinguished between sodium carbonate (natrum) and potassium carbonate (qali). He had some knowledge of arsenious oxide, cupric oxide, antimony and other substances. He knew the toxicological effects of copper and lead compounds, the depilatory virtue of quicklime, the composition of plaster of Paris and its surgical use.

The great Muslim surgeon, Khalaf ibn 'Abbas al-Zahrwi wrote a great medical encyclopedia, al-Tasrif, which contains interesting methods of preparing drugs by sublimation and distillation, but it's most important part is the surgical one.

Ibn Sina wrote a treatise on minerals that provided one of the main sources of geological knowledge, and chemistry in Western Europe until the Renaissance.

The Muslim chemists applied their chemical knowledge to a large number of industrial arts. One of them is mentioned here, which will enable the reader to estimate the extent of their knowledge of Applied Chemistry.

Paper is also featured in the pioneering works of the Muslims. Paper was invented by the Chinese who prepared it from the cocoon of the silk worm. Some specimens of Chinese paper dates back to the second century CE. The first manufacture of the paper outside China occurred in Samarqand in 757 CE. When Samarqand was captured by the Muslims, the manufacture of paper spread all over the Muslims World. By the end of the 12th century, there were four hundred paper mills in Fas alone. In Spain the main center of manufacturing of paper was Shatiba which remained a Muslim city until 1239 CE. Cordova was the center of the paper business in Spain.

The Muslims developed this art. They prepared paper not only from silk, but also from cotton, rags and wood. In the middle of the 10th century the paper industry was introduced into Spain. In Khurasan paper was made from linen. Joseph Karabacek, in one of his works, explains the process of making paper in minute detail, describing how the pulp is prepared to make sheets, washed and cleaned them, colored, polished and pasted. No text comparable to this in any other language exists from that time.

The preparation of pulp involves a large number of complicated chemical processes, which indicates the level of achievement in chemistry reached by Muslims.

The manufacture of writing paper in Spain is one of the most beneficial contributions of Muslim to Europe. Without paper the scale on which popular education in Europe developed would not have been possible. The preparation of paper from silk would have been impossible in Europe due to the lack of silk production there.

The Muslims method of producing paper from cotton could only be useful for the Europeans. After Spain the art of paper making was established in Italy (1268 CE). France owed its first paper mills to Muslim Spain. From these countries the industry spread throughout Europe.

Medicine

Translation of work from other languages
Knowledge of Anatomy
Physiology
Bacteriology
Surgery
Optical work
Operation of Cataracts
Structure of the Eyes
Cesarean operation
Development of Hospitals
Mobile Hospitals
Medical Schools

Centuries before the advent of Islam the Arabs had their own system of medicine in the form of herb and shrubs which was based on Chaldean medicine and on their own experience. Gradually Greek medicine attracted their attention. Harith ibn Kaldah was the first to introduce Greek medicine to the Arabs. Khalid ibn Yazid ibn Mu'waiyah had some Greek and Egyptian books translated into Arabic during the 'Umayyah period. But the science of medicine flourished during the time of the Abbasids.

Initially, the Muslims made arrangements for the translation of Greek, Indian, Persian and Chaldaean medical works into Arabic,

and thus received their knowledge of medicine from these nations. Before they accepted at face value the information they extracted, they conducted research in various branches in medicine to verify what they gathered from these texts.

In addition, they made many valuable new discoveries in medical theory and practical. By combining their discoveries, with the information they filtered from other sources they evolved an entirely new system of medicine.

The Arabs had a fair knowledge of anatomy as it is obvious from the names of the internal and external organs of the human and animal bodies found in the literature of pre-Islamic Arabia. When they became acquainted with the Greek anatomical descriptions, they made investigations on them, pointed out many errors in the work of their predecessors, and made many new discoveries in this field.

In order to verily the Greek anatomical ideas prevailing at that time, Yuhanna ibn Masawaih made dissections of apes supplied to him by the order of the Abbasi Khaleefah Mu'tasim Billah. After this verification he composed his work on anatomy. The works of some Muslim physicians and surgeons, like Tashrih al-Mansuri by Mansur ibn Muhammad, contain illustrations of human organs, which are not found in the Greek works. These illustrations also throw light on the Muslims' practical knowledge of anatomy.

The work of the Muslim physicians in the field of physiology, is quite valuable. For instance, Ibn Nails al-Qarshi of Damascus explained the theory of the minor circulation of blood three centuries before William Harvey, who is credited with this discovery. Also, al-Aarshi suggested that food is fuel for the maintenance of the body's heat. Abu'l-Faraj held that there are canals in the nerves through which sensations and movement are transmitted.

The contributions of Muslims in the field of bacteriology are quite revolutionary. According to Browne, Muslims were fully aware of the theory of germs. Ibn Sina was the first to state that bodily secretions are contaminated by foul foreign earthly bodies before getting the infection. Ibn Khuatimah of the 14th century stated that

man is surrounded by minute bodies that enter the human body and cause disease.

Some Muslims also gave new suggestions regarding the treatment of diseases. Abul-Hasan, the physician of Adud al-Daulah introduced the process of bleeding as a treatment of cerebral hemorrhage which is often due to blood pressure.

Al-Razi suggested nourishing food for the treatment of general weakness. The Muslim physicians were the first to use the stomach tube for the performance of gastric lavage in the case of gas poisoning. They were fully aware of the principles of opotherapy centuries before Browne Sequard, who is ascribed to discovering this method of treatment.

Said ibn Bishr ibn Abdus suggested light foods and cold producing medicines for the treatment of general pardysis and facial pardysis. Ibn al-Wofid gave emphasis upon the treatment of diseases through food control. They discovered the treatment for epidemic jaundice and suggested a reasonable quantity of opium as a treatment of mania. For epistaxis they suggested the pouring of cold water on the head.

In the science of surgery there were also many advancements made by Muslims. They introduced the cauterizing agents in surgery. They were the first to apply the method of cooling to stop the hemorrhage, and suture wounds with silken threads.

It cannot go unnoticed that one of the most famous and eminent figure in Islamic medical field was Ibn Sina, known in the West as Avicenna (981-1037 CE). It is said that for a thousand years he has retained his original renown as one of the greatest thinkers and medical scholars in history. His most important medical works are the Qanun (Canon) and a treatise on Cardiac drugs.

In the 11th century Ibn Zuhr gave a complete description of the operation of tracheotomy, which was not mentioned by the Greeks. Abdul-Qasim al-Zahrawi invented many surgical instruments illustrated in his book al-Tasrif. In the same book he described the

methods of operations for various diseases. While describing the operations of the skull and its parts, the Muslim surgeons made a mention of operations of the uvula and nasal cavity. They also used methods of tonsillectomy and paracentesis of the ear drum.

The Muslim opticians did valuable and original work in the treatment of eye diseases and surgery. Many of the surgical principles formulated by Muslims are still utilized today. The method of operation of cataracts was first described by them. They knew that cataracts were due to the incapacity of the eye lens. Ibn al-Haitham described the structure of the eye and gave revolutionary ideas regarding the mechanism of sight and describing various types of lenses.

The art of midwifery was highly developed by Muslims. Abul-Qasim al-Zahrawi invented the method of Cranicolsy for the delivery of dead fetus and applied it himself. A book entitled Al-Athar al-Baqiyyah in the University of Edinburgh contains an illustration showing an Arab physician performing Cesarean operation.

During the time of Banu 'Umayyah rule, the Muslims developed the institution of hospitals. During the time of the Abbasi Khaleefah Harun al-Rasheed a hospital was built in Baghdad, which was the first in the history of this city. Many new hospitals were established shortly afterwards. Some of them had their own gardens in which the medicinal plants were cultivated. The large hospitals had medical schools attached to them. Besides such hospital there were a large number of mobile hospitals in the Muslim world.

The Muslim hospitals served as models for the hospitals established in different parts of Europe, particularly in Italy and France during the 14th century due to the influence of the Crusades. The Crusaders were inspired by the magnificent hospitals of the Seljuq ruler Nur al-Din in Damascus and those of the Mamluk Sultan al-Mansur Qala'un in Cairo.

Botany and Agriculture

Names of Plants
Method of Plantation
Irrigation & Agricultural Methods
Simple drugs

There was a great scarcity of water and vegetation in the deserts of Arabia. The people living there needed plants to feed their animals. They wandered in search of vegetation, and went wherever they could find it. This great importance of plants resulted in their becoming an important topic of Arabic literature.

The study of plants was chiefly made from medical and agricultural point of view The Arabs already knew about the medical use of some herb and shrubs. When Muslims came in contact with other people, they took interest not only in the names and uses of plants, but they also became interested in their cultivation. They sought to understand matters relating to agriculture such as the methods of plantation and fertilization, the suitable times for sowing and harvesting, and the nature of the soil. They made correct observations on sexual differences between such plants as palms and hemp. The plants were classified into those which grew from cuttings and those which grow from seeds.

The Muslims' knowledge of applied botany and agriculture can be estimated by reading the accounts of gardens and crops cultivated in different parts of the Muslim world, particularly those in Spain. At one time Muslim Spain was proverbial in this respect. The Arabs introduced irrigation and agricultural methods that transformed the region into a garden. Cotton, rice, sugar cane, asparagus, oranges, lemons and pomegranates were some of the plants and fruits brought from outside and cultivated in Spain. Throughout the countries the Europeans became aware of the cultivation of many plants which they did not know before. The famous gardens of Persia, Spain and Morocco, with well planned arrangements of trees, shrubs and flowers, with their filled floors, their rivulets and fountains of water built with an aesthetic taste, establishing harmony between architecture and vegetation, throws light on their interest in agriculture, gardening and love for flowers.

Because the Arabs did not know much about the art of agriculture, they turned towards other peoples including the Romans, Nabateans and Persians for learning it. After they acquired this knowledge, they applied it.

In the 8th and 9th centuries the land of Iraq had a population of 30 million. Eighty percent of the population were farmers. There were modern irrigation systems from the Tigris and Euphrates. The kharaj (land tax) upon irrigated land was 5% versus 10% for land not mechanically irrigated (thereby encouraging agricultural investment). The ratio of yield to seed for wheat in the Muslim world was 10 to 1 compared to 2.5 to 1 in Europe at the time of Charlemagne.

As far as plants themselves are concerned, there were many lexicographers, geographers, travelers and physicians who wrote about them. One of them was Abu Sa'id 'Abd al-Malik ibn Quraib al-Asma'i. He was a native of Basrah, and came to Baghdad during the time of Harun al-Rasheed. Asma'i was born in 739 CE and died in 831 CE. He is the author of a number of works on different subjects. One of them is on plants and trees. In the preface of this book the author provided a general discussion on plants. First he mentions various types of soils having different conditions regarding their capabilities for cultivation and vegetation. Then be mentions the trees, giving an account of their various stages of development. Afterwards he classifies the plants, giving examples of each class. Finally, he describes those plants that grow in plains and deserts. He mentions a total of 230 plants in his book.

Al-Biruni also made observations on plants. He discovered that flowers have 3, 4, 5, 6 or 18 petals, and never 7 or 9.

One of the most important Muslim botanists was Abul-Mansur Rashid al-Din Abul-Fadi ibn 'Ali al-Suri. He was a great authority on simple drugs, the variety of their names, their properties and uses.

Another botanist was Abu Muhammad 'Abd Allah ibn Ahmad al-

Maliqi al-Nabati, known as Ibn al-Bairar. He was renown for identifying the plants by name, species and the places where they grew. He traveled to Roman lands (Asia Minor) and some other territories and observed the plants in the places where they grew. Ibn al-Bairar is the author of many works on simple drugs and other subjects. One of them, Kitab al-Jami fi Adwiyyah al-Mufradah, is mainly based on the works of his Greek and Muslim predecessors, but also contains his personal observations made in different lands. He gave in alphabetical order, the Persian, Latin and Berber names of the simple drugs and also cleared the confusion in the names. He also mentioned their properties and uses.

Geography

Reason for studying Geography
Vastness of the State
Prayer direction
Hajj
Earth is round
Naval Science
Drawing of world map

The Muslims had to travel to distant lands across plains cities, deserts, mountains, rivers and seas during trade, military expedition and the administration of their vast state. Within one hundred years after the advent of Islam, their state stretched from Arabia to India in the East, and Morocco and Spain in the West. In the 10th century, the Islamic State comprised the territories of Arabia, Egypt with the entire Northern coast of Africa, nearly the whole of Spain, the islands of Sicily, Greece, some Italian towns, Syria, South East of the Caucasus, Mesopotamia including Iraq, the whole of Modern Persia, Afghanistan, Transsoxania, and lower territories of Indus. Travels in these vast lands and their administration necessitated the accumulation of information on them.

The science of geography is somewhat related to astronomy. Therefore, the study of geography was also motivated by the same incentive as astronomy, which was the need for determination of the direction of the Ka'bah for the orientation of the mosque and for turning faces towards it during the time of prayer.

Another great factor that motivated the study of geography was the annual Hajj. Before leaving for Hajj, the pilgrims generally collected information on the territories which lay on the way to Makkah. To provide such information many itineraries were from different countries to Makkah were shown. In the early days, the information on various lands and its people was supplied mainly by the trader and travelers. In addition, Muslim traders were very active in those days. They reached as far as China, Russia, Zanjibar and the southern tip of Africa.

A large number of books on geography were produced by Muslim geographers and travelers which were widely studied. The translations of these books were made into many European languages and for centuries the Europeans acquired the knowledge of the world through these books. Until modem times they depended for their knowledge of Africa on the works of Hasan al-Wazzari (Leo Africanos) who wrote an account of his travels to the end of the 16th century.

The development of naval technology was launched during the time of the second Khaleefah 'Umar ibn al-Khattab, when the Muslims started to build the navy. This navy sailed from the ports in Syria and Egypt. Mu'awiyah stationed it in the sea adjacent to Cyprus until this region was opened to Islam in 28 AH/649 CE. During the time of the third Khaleefah, 'Uthman ibn 'Affan, the Islamic navy defeated the Roman navy which was under the command of the emperor Constantine, son of Heraclius, in the famous battle of Umm as-Sawari (the Mother of Masts) in 34 AH/654 CE.

Among the well known admirals of the Islamic navy were 'Adullah ibn Abu al-Sarh, who led the battle of Umm as-Sawari, and Ahmad ibn Deenar ibn 'Abdullah who defeated the Roman navy in 232 AH/856 CE, at the time of the Abbasid Khaleefah al-Mutawakkil.

The Muslims opened up the land routes to India, China, Malaysia, and Timbuktu, the emporium of Central African trade, and sent their

caravans to the rich lands beyond the Sahara long before the Portuguese reached Cape Verde. They controlled the sea routes to India, and the Emosiads founded along the Eastern coast of Africa a line of trading colonies from the Sudan Coast and Socotra to Mombassa, Mozambique, Zanzibar and Madagascar.

The seventh Abbasi Khaleefah al-Ma'mun took a keen interest in geography. He appointed seventy scholars to draw a large map of the world. One of these scholars, Ibn Musa al-Khwarizmi, compiled a geographical work called Rasm al-Ma'mur min al-Bilad (Description of the Inhabited Lands) which contains the results of the research of these scholars. He made improvements on Ptolemy's geographical work, both in the text and in the maps. He followed Ptolemy in giving the latitudes and longitudes of various places. He also gave the geographical positions of the places which originated after the rise of Islam.

The narrative of a Muslim merchant named Sulaiman who undertook travels to China and to many coast lands of the Indian Ocean appeared in 851 CE. It is the first description of these lands in the Arabic language. It throws light on the commercial relations between the Chinese and Muslims during the first half of the 10th century CE.

Another geographer, botanist, lexicographer and historian named 'Abd Allah ibn 'Abd al-Aziz al-Bikri wrote valuable books on many subjects. The kings of the Spanish territories used to send their books to one another as gifts. One of these books is a geographical work called Kitab al-Masalik wa'l Mamalik, written by al-Bikri. It is in the form of an itinerary and contains historical and ethnographic information. In addition, he also composed a geographical dictionary mainly of Arabia.

One of the travelers and geographers of the same period was Abu 'Abd Allah ibn 'Abd al-Raheen al-Gaharnati, who was born in Granada in 1080 CE. He traveled from Spain to Egypt, via Sarinia and Sicily. He went to Baghdad, Abhor and Jibal Sakhsin on the upper Volga. He also traveled to Bulgaria, Bashgird and Hungary. He is the author of many geographical works. His descriptions of the foreign countries are largely anecdote. One of his works is entitled Tuhfat al-Albab wa Nukhbat al-Aiaib, which provides a description of the world and its inhabitants, natural phenomena of various countries and strange geographic oddities.

Another illustrious scholar of this age and the greatest geographer of the Middle Ages was Abu 'Abd Allah Muhammad ibn Muhammad ibn 'Abd Allah, usually called al-Sharid al-Idrisi. He was also a historian, botanist, traveler, literary scholar and a poet. He was brought up at Cordova where he received his education. Then he undertook long journeys in the Mediterranean region until last he reached Sicily.

Al-Idrisi began to compile his monumental work on the world geography entitled Kitab al-Ruuri which was completed in 1154 CE. It is the most comprehensive work ever written on medieval history and geography. It is the best Arabic work on the description of Europe. The later Muslim geographers derived information on Europe from this celebrated work.

A Muslim geographer of the 13th century was Abul-Hasan 'Ali ibn Musa ibn Muhammad al-Maghribi. He was also a historian and a poet. He traveled extensively and visited Egypt, Syria and Iraq. He was the guest of Hulagu II. In 1251 CE during his stay in Baghdad 'Ali ibn Musa visited 36 libraries in that city. He had the knowledge of the mouth of the river Senegal. He gave an account of the northern countries of Europe where white bears are found. He mentioned that Iceland is called the island of white falcons and that the true falcons are found in Denmark.

The Present Situation and Regaining the leadership in Science and Technology

The Muslim world today is characterized with failure, disunity and stagnation in science and technology. Despite the fact that the Muslims have enormous wealth, they still lag behind in industrial development. This sad state of affairs is not the result of following Islam. Rather, it is a direct result of NOT following Islam. The

constitutions, laws, and way of thinking which prevail in the Muslim world today are derived from secular origins. They have nothing to do with Islam whatsoever, but are established upon man-made ideas and concepts.

When Islam prevailed as a way of life, with its own political, economic, social, educational and judicial system, Muslims and non-Muslims in the Islamic State enjoyed peace and security. The development of science was stimulated by the Qur'an itself and the Muslims rapidly became the leaders in the field of science and technology.

The decline of science and technology in the Muslim world came about as a result of complacency in the understanding and implementation of Islam. Study and understanding of Arabic was allowed to decline, ijtihad was abandoned and the doors were opened for the missionary, cultural and political invasions of the West. These factors effectively sealed the fate of the Islamic State itself, and by the turn of the 20th century CE, the Islamic State was not in a position to keep itself intact against the European onslaught.

The existing stagnation in the development of science is therefore attributed to the complacency of adhering to Islam as a way of life, i.e. to the ideology of Islam. No nation can progress, scientifically or otherwise, if it does not adopt an ideology, and the Muslims are no exception to this rule. The West has adopted Capitalism and progress has been achieved in many areas of life as a result. The East was forced to adopt Communism and it also achieved a certain amount of material progress, especially in science and technology.

The only way in which Muslims can assume the leadership once again in the field of science and technology is through the comprehensive adherence to Islam as an ideology, i.e. complete adoption of the Islamic creed and implementation of all the systems of Islam. This leadership in science and technology is required from the Muslims in order to carry the pure message of Islam to the world, which cannot be accomplished except by striving to prepare the Muslims with what can resist the material forces of those who oppose the call of Islam.

The application of Islam will provide an environment that will be very conducive for research and development. Proper resources will be allocated to colleges, universities and research centres. Solving technical problems, improving efficiency of industrial processes, finding cures for diseases and enhancing material life as much as possible will be amongst the objectives in the policy of the State. Ideas turned into practical applications to improve the lives of people will be encouraged. In fact, industrialization (both light and heavy industries) will be the priority of the Islamic State and there is not a shred of doubt that in a short spell of time the Islamic State will once again lead the world in science and technology, and it will become the beacon of attraction for study of Information Technology, Medicine, Natural Sciences, Space and Genetic Technology, as well as in life's affairs and in addressing the needs of humanity.

Conclusion

Any objective observer will notice that science stagnated under the Christian Church in Europe It was impossible to implement Christianity upon society because it is not a detailed and comprehensive societal way of life like Islam. However, science bloomed under Islam, and the Muslim world enjoyed its golden period when Europe was steeped in the Dark Ages. Islam, is the complete code of life from the Creator that obligates human progress based upon thought, by which man is distinguished far above the level of animals.

Very little is revealed in the West about the glorious history of Islam. If the educational systems of the West began to disclose information about the scientific and technological revolutions of the Muslims and about how Islam looked after the affairs of humanity, the long standing dogma that Capitalism has perpetuated among its people that religion has no applicability in the worldly life would be subjected to doubt as people would turn to Islam with a fresh new perspective.

People from different nations and cultures were moulded by Islam

into a society in which the life, honor, and property of every citizen, Muslim and non-Muslim, was secure Furthermore, Islam broke the shackles of ignorance that had engulfed humanity and provided a system in which Muslims and non-Muslims excelled, among other things, in science and technology.

Notes and References

[1] Religion - The word religion has been used in the West to denote man's relationship with his Creator. It manifests itself in the rituals, practices and norms that deal with spiritual aspect of man, and not the temporal affairs. However, Islam is not simply a religion, although it has rules for rituals and worships, but it is a comprehensive way of life with a system for politics, economics, social relations, foreign and military affairs and so on. Islam is an ideology.

[2] AH - After Hijrah (Migration). Islamic calendar starts from the time when Prophet Muhammad ﷺ migrated from Makkah to Madinah to establish the first Islamic State. This state lasted until the end of the 'Uthmani (Ottoman) rule in 1924 CE.

[3] Capitalism - A way of life that results from the detachment of religion from the state. Religion is confined to individual worships and rituals and the state is run according to man-made laws. Man's liberties, namely, freedom of action, freedom of belief, freedom of speech and freedom of ownership of capital become the guiding principles in all aspects of man's life. These principles form the new 'religion'. Since the freedom of ownership of capital is the most prominent of the four liberties, this ideology has taken its name from it i.e. Capitalism.

[4] Islamic State - Khilafah in Arabic, Caliphate in English. The State that was established by Prophet Muhammad ﷺ in 622 CE in the city of Madinah. In this State, Islamic Law was the supreme law of the land. All matters related to foreign policy, politics, economics, education, social relations and judiciary were based on the sources of Islam, the Qur'an and the Sunnah (example of Prophet Muhammad (saw)). The Islamic State constituted North Africa, Middle East, parts of the Indian sub-continent, the Balkans, Spain and the former southern Soviet republics. In the run up to its dismantlement by Britain and France in 1924, it was labeled as the Ottoman State. The Islamic State therefore existed for 1302 years.

There is no distinction or separation between religion and state, neither is there a clerical structure or authority. The Islamic State is not a divine or a holy state. The Islamic state is neither a religious/theocratic state, nor a spiritual authority established to have the side of the spirit outweigh the side of matter.

The Islamic State is established to rule and govern the affairs of the people based upon one intellectual and ideological creed from which the systems of life are

derived, which are implemented and executed by the State.

[5] Khaleefah - Caliph, Head of the Islamic State. Khaleefah is the central authority of the Muslims, who is contracted by Muslims to implement Islamic laws (in all aspects of their lives) on them. Unfortunately at the time this book was written, no such authority exists in the Muslim world.

[6] Jihad - Every nation has a foreign policy through which it carries its ideology to the other nations. The foreign policy depends on two elements; diplomacy and force. When diplomacy fails using force becomes inevitable. Having this in mind, the Islamic State has specific responsibilities to carry its agenda. Therefore, the term Jihad means utilizing diplomacy and force in the foreign policy of the Islamic State.

[7] Hajj - Pilgrimage. It is one of the obligations of Islam which a Muslim must perform if he is financially and physically able to. It is annual, but needs to be performed only once in a Muslims' lifetime. It is a 'pilgrimage' to Makkah, in accordance to the method in which Prophet Muhammad ﷺ performed it.

[8] The medium of communication in the field of science, especially between 800-1500 CE, throughout the Muslim world was Arabic. All scientific works were written in Arabic, which is the language of Islam, and naturally, was the language of the Islamic State. It is only after colonization of Muslim lands that this practice became less prevalent or eliminated in many instances.

Appendix I

What they say about the contribution of Muslims to Science and Technology

Note: The following quotes contain words or terms that are often misleading. Please bear the following in mind:

Where the word or terms is used:	*Actually refers to, and should be taken as:*
Arabs or Muhammadans	**Muslims**
Muslims and Arabic civilization	**Islamic Civilization**
Saracen(ic) and Moor(ish)	**Muslims (Arabs and non-Arabs)**

John William Draper in the "Intellectual Development of Europe"

"I have to deplore the systematic manner in which the literature of Europe has continued to put out of sight our obligations to the Muhammadans. Surely they cannot be much longer hidden. Injustice founded on religious rancour and national conceit cannot be perpetuated forever. The Arab has left his intellectual impress on Europe. He has indelibly written it on the heavens as any one may see who reads the names of the stars on a common celestial globe."

Robert Briffault in the "Making of Humanity"

"It was under the influence of the arabs and Moorish revival of culture and not in the 15th century, that a real renaissance took place. Spain, not Italy, was the cradle of the rebirth of Europe. After steadily sinking lower and lower into barbarism, it had reached the darkest depths of ignorance and degradation when cities of the Saracenic world, Baghdad, Cairo, Cordova, and Toledo, were growing centers of civilization and intellectual activity. It was there that the new life arose which was to grow into new phase of human evolution. From the time when the influence of their culture made itself felt, began the stirring of new life.

It was under their successors at Oxford School (that is, successors to the Muslims of Spain) that Roger Bacon learned Arabic and Arabic Sciences. Neither Roger Bacon nor later namesake has any title to be credited with having introduced the

experimental method. Roger Bacon was no more than one of apostles of Muslim Science and Method to Christian Europe; and he never wearied of declaring that knowledge of Arabic and Arabic Sciences was for his contemporaries the only way to true knowledge. Discussion as to who was the originator of the experimental method....are part of the colossal misinterpretation of the origins of European civilization. The experimental method of Arabs was by Bacon's time widespread and eagerly cultivated throughout Europe.

Science is the most momentous contribution of Arab civilization to the modern world; but its fruits were slow in ripening. Not until long after Moorish culture had sunk back into darkness did the giant, which it had given birth to, rise in his might. It was not science only which brought Europe back to life. Other and manifold influence from the civilization of Islam communicated its first glow to European Life.

For Although there is not a single aspect of European growth in which the decisive influence of Islamic Culture is not traceable, nowhere is it so clear and momentous as in the genesis of that power which constitutes the permanent distinctive force of the modern world, and the supreme source of its victory, naturd science and the scientific spirit.

The debt of our science to that of the Arabs does not consist in startling discoveries or revolutionary theories, science owes a great deal more to Arab culture, it owes its existence. The Astronomy and Mathematics of the Greeks were a foreign importation never thoroughly acclimatized in Greek culture. The Greeks systematized, generalized and theorized, but the patient ways of investigation, the accumulation of positive knowledge, the minute method of science, detailed and prolonged observation and experimental inquiry were altogether alien to the Greek temperament. Only in Hellenistic Alexandria was any approach to scientific work conducted in the ancient classical world. What we call science arose in Europe as a result of new spirit of enquiry, of new methods of experiment, observation, measurement, of the development of mathematics, in a form unknown to the Greeks. That spirit and those methods were introduced into the European world by the Arabs.

It is highly probable that but for the Arabs, modern European civilization would never have arisen at all; it is absolutely certain that but for them, it would not have assumed that character which has enabled it to transcend all previous phases of evolution."

Arnold and Guillaume in "Lagacy of Islam" on Islamic science and medicine

"Looking back we may say that Islamic medicine and science reflected the light of the Hellenic sun, when its day had fled, and that they shone like a moon, illuminating the darkest night of the European middle Ages; that some bright stars lent their own light, and that moon and stars alike faded at the dawn of a new day - the Renaissance. Since they had their share in the direction and introduction of that great movement, it may reasonably be claimed that they are with us yet."

George Sarton in the "Introduction to the History of Science"

"During the reign of Caliph al-Mamun (813-33 CE), the new learning reached its climax. The monarch created in Baghdad a regular school for translation. It was equipped with a library, one of the translators there was Hunayn Ibn Ishaq (809-77) a particularly gifted philosopher and physician of wide erudition, the dominating figure of this century of translators. We know from his own recently published Memoir that he translated practically the whole immense corpus of Galenic writings.""

"Besides the translation of Greek works and their extracts, the translators made manuals of which one form, that of the 'pandects,' is typical of the period of Arabic learning. These are recapitulations of the whole medicine, discussing the affections of the body, systematically beginning at the head and working down to the feet."

"The Muslim ideal was, it goes without saying, not visual beauty but God in His plentitude; that is God with all his manifestations, the stars and the heavens, the earth and all nature. The Muslim ideal is thus infinite. But in dealing with the infinite as conceived by the Muslims, we cannot limit ourselves to the space alone, but must equally consider time.

The first mathematical step from the Greek conception of a static universe to the Islamic one of a dynamic universe was made by Al-Khwarizmi (780-850), the founder of modern Algebra. He enhanced the purely arithmetical character of numbers as finite magnitudes by demonstrating their possibilities as elements of infinite manipulations and investigations of properties and relations.

In Greek mathematics, the numbers could expand only by the laborious process of addition and multiplication. Khwarizmi's algebraic symbols for numbers contain within themselves the potentialities of the infinite. So we might say that the advance

from arithmetic to algebra implies a step from being to 'becoming' from the Greek universe to the living universe of Islam. The importance of Khwarizmi's algebra was recognized, in the twelfth century, by the West, - when Girard of Cremona translated his theses into Latin. Until the sixteenth century this version was used in European universities as the principal mathematical text book. But Khwarizmi's influence reached far beyond the universities. We find it reflected in the mathematical works of Leonardo Fibinacci of Pissa, Master Jacob of Florence, and even of Leonardo da Vinci."

"Through their medical investigations they not merely widened the horizons of medicine, but enlarged humanistic concepts generally. And once again they brought this about because of their over riding spiritual convictions. Thus it can hardly have been accidental that those researches should have led them that were inevitably beyond the reach of Greek masters. If it is regarded as symbolic that the most spectacular achievement of the mid-twentieth century is atomic fission and the nuclear bomb, likewise it would not seem fortuitous that the early Muslim's medical endeavor should have led to a discovery that was quite as revolutionary though possibly more beneficent."

"A philosophy of self-centredness, under whatever disguise, would be both incomprehensible and reprehensible to the Muslim mind. That mind was incapable of viewing man, whether in health or sickness as isolated from God, from fellow men, and from the world around him. It was probably inevitable that the Muslims should have discovered that disease need not be born within the patient himself but may reach from outside, in other words, that they should have been the first to establish clearly the existence of contagion."

"One of the most famous exponents of Muslim universalism and an eminent figure in Islamic learning was Ibn Sina, known in the West as Avicenna (981-1037). For a thousand years he has retained his original renown as one of the greatest thinkers and medical scholars in history. His most important medical works are the Qanun (Canon) and a treatise on Cardiac drugs. The 'Qanun fi-l-Tibb' is an immense encyclopedia of medicine. It contains some of the most illuminating thoughts pertaining to distinction of mediastinitis from pleurisy; contagious nature of phthisis; distribution of diseases by water and soil; careful description of skin troubles; of sexual diseases and perversions; of nervous ailments."

"We have reason to believe that when, during the crusades, Europe at last began to establish hospitals, they were inspired by the Arabs of near East....The first hospital in Paris, Les Quinze-vingt, was founded by Louis IX after his return from the crusade 1254-1260."

"We find in his (Jabir, Geber) writings remarkably sound views on methods of chemical research, a theory on the geologic formation of metals (the six metals differ essentially because of different proportions of sulphur and mercury in them); preparation of various substances (e.g., basic lead carbonatic, arsenic and antimony from their sulphides)."

"Ibn Haytham's writings reveal his fine development of the experimental faculty. His tables of corresponding angles of incidence and refraction of light passing from one medium to another show how closely he had approached discovering the law of constancy of ratio of sines, later attributed to snell. He accounted correctly for twilight as due to atmospheric refraction, estimating the sun's depression to be 19 degrees below the horizon, at the commencement of the phenomenon in the mornings or at its termination in the evenings."

"A great deal of geographical as well as historical and scientific knowledge is contained in the thirty volume meadows of Gold and Mines of Gems by one of the leading Muslim Historians, the tenth century al Mas'udi. A more strictly geographical work is the dictionary 'Mujam al-Buldan' by al-Hamami (1179-1229). This is a veritable encyclopedia that, in going far beyond the confines of geography, incorporates also a great deal of scientific lore."

"They studied, collected and described plants that might have some utilitarian purpose, whether in agriculture or in medicine. These excellent tendencies, without equivalent in Christendom, were continued during the first half of the thirteenth century by an admirable group of four botanists. One of these Ibn al-Baitar compiled the most elaborate Arabic work on the subject (Botany), in fact the most important for the whole period extending from Dioscorides down to the sixteenth century. It was a true encyclopedia on the subject, incorporating the whole Greek and Arabic experience."

"'Abd al-Malik ibn Quraib al-Asmai (739-831) was a pious Arab who wrote some valuable books on human anatomy. Al-Jawaliqi who flourished in the first half of the twelfth century and 'Abd al-Mumin who flourished in the second half of the thirteenth century in Egypt, wrote treatises on horses. The greatest zoologist amongst the Arabs was al-Damiri (1405) of Egypt whose book on animal life, 'Hayat al-Hayawan' has been translated into English by A.S.G. Jayakar (London 1906,

1908)."

"The weight of venerable authority, for example that of Ptolemy, seldom intimidated them. They were always eager to put a theory to tests, and they never tired of experimentation. Though motivated and permeated by the spirit of their religion, they would not allow dogma as interpreted by the orthodox to stand in the way of their scientific research."

References for Appendix I taken from 'Muslim History 570-1950 CE' by Akram Zahoor:

1. *George Sarton, "Introduction to the History of Science, Vol. I-IV," Carnegie Institute of Washington, Baltimore, 1927-31; Williams and Wilkins, Baltimore, 1950-53.*
2. *Robert Briffault, "The Making of Humanity" London, 1938.*
3. *Thomas Arnold, "The Legacy of Islam" Oxford University Press, 1960.*
4. *T. Arnold and A. Guillaume, "The Legacy of Islam" Oxford University Press, 1931.*
5. *E.G. Brown, "Arabian Medicine" Cambridge, 1921.*
6. *D. Campbell, "Arabian Medicine and its influence on the Middle Ages" London, 1926.*
7. *P.K. Hitti, "A History of Arabs" London, 1937; MacMillan, 1956.*
8. *Carra de Vaux, "Legacy of Islam" and "The Philosophers of Islam" Paris, 1921; "Les Penseurs de l'Islam" 5 Vols., Paris, 1921-26.*
9. *De Lacy O'Leary, "Arabic Thought in History."*
10. *Joseph Hell, "The Arab Civilization" Tr. Khuda Baksh, Lahore 1943.*
11. *Silberberg, "Zeitschrift fuer Assyriologie" Strassburg, Vols. 24-25, 1910-1911.*
12. *E. Gibbon, "Decline and Fall of Roman Empire" London, 1900.*

Appendix II

Topical lists of European/Latin words with Arabic origins. Some of the popular words used in the field of science have their roots in Arabic. No doubt this indicates that the Muslims were far ahead of the Europeans when it came to scientific progress.

Names of Stars

English/Latin Name	Arabic Name
Achernar	*Akhir al-Nahr*
Acrab	*Aqrab (Scorpion)*
Aega	*Nasr al-Waqi*
Aldebaran	*ad-Dabaran*
Altair	*Nasr al-Tair*
Daneb	*Dhanab al-Dujajah*
Denebola	*Dhanab al-Asad*
Fomal Haut	*Famm al-Hut*
Phurked	*Farqad (calf)*

Mathematical Vocabulary

English/Latin Name	Arabic Name
Algebra	*al-Jabr*
Algorism, Algorithm	*Al-Khwarizmi*
Atlas	*Atlas*
Average	*Awariya*
Azimuth	*Al-sumut*
Cipher, Zero	*Sifr*
Nadir	*Nadir, Nazir*
Zenith	*Cenit*

Medical Terms

English/Latin Name	Arabic Name
Alcanfor, Camphor	Kafur
Alchemy, Chemistry	Al-kimiya
Alcohol	al-khul
Anima	Kitab al-Nafs
Antimonio, Antimony, Antimun	Antimun, Ithmid
Benzene	Luban-Jawi
Colliget	Al-Kullyat
Elixir	al-Aksir
Sufficientia	Kitab al-Shifa
Zircon	Azraq

Names in Chemistry and Other Frequently Used Words

English/Latin Name	Arabic Name
Admiral	Amir al-Bahr
Adobe	Al-tub
Alcove	Al-qubba
Alembic	Alembic
Alkali	Alkali
Aludel	Aludel
Alum	Alum
Amber	Anbar
Arsenal	Dar al-Sina'ah
Artichoke	Al-Kharshuf
Athomor	Athomor
Azymum	Azymum
Banana	Banana
Cable	Habl
Calibre	Qalaba
Camel	Jamel
Canon	Qanun
Checkmate	Shah Mat
Cinnabar	Cinnabar

Cipher	Sifr
Coffee	Qahwa
Cotton	Qutun
Earth	Ardh, Earz
Gibberish	Jabir ibn Hayyan
Giraffe	Zurafa
Hazard	Al-Zahr
Jasmine	Yasmin
Jumper	Jubbah
Lemon	Limun
Lute	Al-'ud
Magazine	Makhazin
Monsoon	Mawsim
Musk	Musk
Orange	Naranj
Rice	Ruzz
Safari	Safara
Safron	Za'faran
Sugar	Sukkar
Syrup	Shurb, Sharab
Tutia	Tutia
Usefur	Usefur
Ziniar	Ziniar

Anatomical Terms

English/Latin Name	Arabic Name
Aorta	Avarta
Basilie	Baslik
Cephallie	Kifal
Colon	Colon
Corn	Corn
Cornea	Cornea
Diaphragm	Dayafergma
Epidemis	Aghadidus
Mennigies	Mennigies

Mesentry	*Masarike*
Pancreas	*Bankras*
Peritoneum	*Baratene*
Sephenous	*Safan*
Trochanter	*Tracanter*