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Contribution of Islamic Civilization to the Field of Science and Technology

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Abstract: The advent of Islam in the sixth century resulted in the formation of a new empire and a world civilization. With the rise of Islam, Muslims had made immense leaps forward in the area of Science and Technology. The Contribution of Islamic Civilization to Science and Technology from the 8th to 16th century is a noteworthy expansion in human antiquity. The Muslim Scientists not only conserved the ancient knowledge, but also transformed it into major new contributions to the basic science and technology. Muslim Scientists significantly contributed to human knowledge in various fields through their innovations. This contribution was so great that Islamic civilization has been the pioneer of the scientific, intellectual and cultural genius for a long period of time. This paper, therefore analyses the contributions of Islamic Civilization with particular references to sciences. It affirms that Islam is beyond only the religion of prayers and rituals. This paper will also try to shed a light on few works that have been carried out by the Muslim Scientists with a brief explanation on their work on applied sciences like Mathematics, Astronomy, Chemistry, Physics, Medicine and other branches of modern science.

Keywords: Islamic Civilization. Muslims Scientists, Modern Science, Advance Technology.

INTRODUCTION

Islam has its own golden history almost in every sectors of knowledge. Islam torches every aspect of human life for the growth, development and advancement of society. Acquisition of knowledge of humanity, social sciences as well as the pure and applied sciences is comprehensively expressed in Islamic education. Islamic civilization plays high premium on technological advancement that established the spirited and essential base of modern science and technology. The story of the Muslim sciences takes the form of fascination of knowledge from different civilizations, accumulating their original and significant contributions, and increasing knowledge across countries and regions through trade, cultural interactions, and education. In Islam, science, the study of nature, is linked to the concept of "*Tawhid"* the Oneness of God. This is so because; Muslims are called to reflection of the creations of *Allah*. The Qur'an explains how *Allah* has honoured man over and above other creatures, such that he is empowered to go into the sky and deep into the sea [1]. In Islam, nature is not seen as a separate entity, rather as an integral part of Islam's holistic outlook on God, humanity and the world. This link implies a sacred aspect to the pursuit of scientific knowledge by Muslims, as nature itself is viewed in the Qur'an as a compilation of signs pointing to the Divine. By and large, the study of various aspects of sciences and arts flourished and brought development and honour to humanity. Subjects like Mathematics Physics and Medicine, Astronomy, Chemistry, Geography and Agriculture. Others are: Philosophy, Literature, Theology and Grammar. In Islam**,** Science is the pursuit of knowledge and understanding of the natural and social world following a systematic methodology based on evidence.

The Quranic Views on Science

The Quran is not a book of science but a book of signs. However, there are more than six thousand 'signs' in the Quran deal with science. One of the most remarkable things about the Qur'an is that it contains many verses, which correctly describe natural phenomena in various disciplines such as human embryology, meteorology, astronomy, geology, and oceanography. Many of the processes and functions mentioned in the Qur'an have been discovered only recently. Some examples are the Big-Bang Theory, Sex Chromosomes, Sex determination, solar orbit, human embryology, etc. However the Qur'an is not meant to be a "Textbook of Science". The Quran, the main source of the Islamic faith is a book believed by Muslims to be of completely Divine origin. Muslims believe that it contains guidance for all mankind. Since the message of

the Quran is believed to be for all times, it should be relevant to every age. The Holy Qur'an is not intended to be a book of Science; however, it contains many references to scientific facts in the context of the Divine plan and the working of the universe and to show the all inclusive knowledge of its Creator, the omnipotent God, only a partial listing of verses of the Quran dealing with science. The Holy Quran frequently requests Muslims to travel for knowledge and to communicate with other cultures. The holy Quran was the dynamic force behind the development of sciences in the early history of Islamic civilization. The Quran shows the relationship of God, nature and man as central worldview which inspired for study of the natural phenomena. The early Muslim Scientists motivated by the revealed knowledge studied nature in the context of the Quranic worldview. Guided by the divine sources they were able to make great achievements in science, technology and civilization. The Qur'an has proved an important stimulus to learning. The word *Ilm* "knowledge" occurs in the Qur'an about 750 times [2]. One of the highest word counts in the text and one of the most repeated words in the Traditions of the Prophet Muhammad. The Qur'an strongly emphasizes the beauty of nature and presence of God's miracles in the physical world. In many places the Qur'an references nature and elements of science and connects these with God's creation, even encouraging scientific research [3]. Islam does not merely consist of religious rituals; it consists of both religion and the law. All public and private aspects of life are taken into account in it and for each one some guidelines have been provided. In Islam, there is a relationship between human nature and religious obligations. In these two fields, all legal applications are interconnected [4]. Early Muslim scholars had already concluded the earth was round based on their interpretation of a description in the holy Qur'an.

Modern Science and Islam

The purpose of Islam is to awaken in man the higher consciousness of his manifold relations with God and the universe." The character of the universe in the Qur'an is that of a dynamic, active, and ever-growing universe. One of the most remarkable qualities of the Quran is the complete consistency between most of the discoveries of modern Science and the Quran. The Qur'an expatiates that God created the heavens and earth in six separate layers [5], the earth was created in two eras [6]. The heavens form layers, one above the other [7]. The angels inhabit the seventh heavens. The lowest heaven is adorned with lights [8], the sun and the moon which follow a regular path [9], the stars and the constellations of the Zodiac [10] among others. Sciences are explicitly explained in the Quran as branches of knowledge for the need of man. These include those that are relating to modern biology, botany, zoology, chemistry, physics, electricity, heat light, scales, and measurements, sound and weight. Other knowledge raised in the Holy Qur'an includes agricultural sciences to consist farming, horticulture, and irrigation. Among other considerations in the realm of science in the Holy Book is health science which includes physiology, psychiatry psycho-analysis, dietary regulations and medicine. The holy Qur'an also calls for general reflections on other branches of natural science concerning the sky, water cycle and seas, the earth atmosphere and its relief, geology and mineralogy and of course geography and anthropology. The Qur'an explained how God created everything in the universe and brought all lives out of water. He created humans from earth and there is no need to attempt fabrications of "links" to the animal world in Islam. This is expressed by a number of references from the Qur'an verses. The Quran says: "And *Allah* has created every living thing from water; of them are some creeping on their bellies; some walk on two legs; and some on four. Allah creates what He wills: for sure Allah has Power over all things [11].

In Islam the purpose of nature is for man 'to study nature in order to discover God and to use nature for the benefit of mankind'. Nature can be used to provide food for mankind and its bounty is to be equally distributed among all peoples. Furthermore science from an Islamic outlook must show the interrelatedness of all parts of the universe. According to Islamic teaching, the God summons humanity to investigate and reflect upon the heavens, the earth, mountains, stars, plants, seeds, animals, the alternation of the night and the day, the creation of man, the rain and many other created things. Examining these, man comes to recognize the artistry of Allah's creation in the world around him, and ultimately, to know the Creator, Who created the entire universe and everything in it from nothing.

The Progress of Islamic Civilization

The Islamic civilization, which had been a major source of knowledge and morality; and given birth to a great nation that brought peace, prosperity and development to the humankind. Islam and its followers had created a civilization that played very important role on the world stage for more than a thousand years. One of the most important specific qualities of the Islamic civilization is that it is a well-balanced civilization that brought together science and faith. This is what distinguishes the Islamic civilization from other civilizations which attach primary importance to the material aspect of life, physical needs and human instincts. Islamic Civilization which may be synonymous to *Tawhidic* civilization is based on a unity of God which stands completely against any racial or ethnic discrimination. The most important specific characteristic of Islamic civilization is that it is a civilization of balance and middle way, because it has united learning and faith, established a balance between the spirit and matter, and it hasn't separated this world from the next. Islam was not opposed to learning from

the earlier civilizations and incorporating their science, learning, and culture into its own world view. The Islamic worldview equipped Islamic scholarship with unity of philosophy of science.

In the golden era of Islamic civilization, scientists were financially sponsored by rulers of the Islamic empire. That was clearly illustrated by the establishment of institutions of advanced learning, such as *Baitul Hikmah* "House of Wisdom", *Al-Nazzamiyyah* Schools of Baghdad, and other institutions and centres of higher learning. The reformation and revivalism discourse in Islamic civilization is original and deeply rooted in Islamic tradition. Islamic civilization produced great achievements and the intellectual legacy of a faith that transformed the world. Islamic civilization at its height was the model of human progress and development. Islam was one of the world's leading civilizations for a thousand years. Its language Arabic was the international language of science [12].

The Islamic civilization penetrated into Europe through trade, crusades, translation of hundreds of Arabic books into Latin. Hence, Islamic civilization transmitted them to Europe and prepared the ground for scientific development in the West. Due to influence of Islamic teachings and due to their turning to sciences, Muslims progressed rapidly in all different aspects of civilization including the arts, architecture, fine arts, textile industry, geography, discoveries, physics, chemistry, medicine, Astronomy, botany and agriculture, irrigation, music, calligraphy, urban development, book and library, religious sciences so forth and so on. They founded the brilliant Islamic civilization even no one can deny its impact on Europe. Muslims scholars who have marked the history of universal science by their discoveries and innovations in the humanities science, mathematics, medicine and technology, gave it credits to Islamic civilization.

The development of science under Islamic civilization between the 8th and 16th centuries is known as the Islamic golden age. It is also known as Arabic science since the majority of the texts during this period were written in Arabic, the *lingua franca* of Islamic civilization. The scientific method has been greatly inspired by Muslim scientists who introduced a modern empirical, experimental and quantitative approach to scientific inquiry. As part of its contributions to knowledge, "House of Wisdom" *Bayt al–Hikinah* was founded by Abbasid Caliph Ma'mum in Baghdad to be a centre of science [13]. He was a great scholar and a lover of scholarship. He gave liberal patronage to men of learning and encouraged scholarly discussions in his court. Thus, his court became the resort of philosophers, astronomers, physicians, scientists, poets and other men of letters. There were adequate provisions for scholars and students to remain in this academy for study and students came from various parts of the world to this academy.

The Impact of Islamic Civilization on Western Culture

By the sixteenth century, Islamic civilization was among the most widespread and important civilizations on earth. Islamic civilization's achievements and positive contributions to the world and the European Renaissance have not received due recognition. Islam was the first to create a civilisation that was multiracial, multicultural and intercontinental. The Renaissance and modern Western civilization owe much more to Islamic civilization than has been acknowledged. They have also noted that Islamic civilization was neither dogmatic nor exclusive in its dealings with non-Muslims. Islam was the first to make significant progress towards what it perceived as its universal mission while western civilization is accorded the first to embrace the whole planet. The influence of the Islamic civilization over Western culture was so great and diverse that it is visible even today in many of the names of things and articles of ordinary use. Science owes a great deal more to Arab culture.

From the fifth century BC, *Jabir b. Hayyan* d. 200AH/815AD Geber in Medieval Europe was said to be the first Muslim Scientist to appear between 750-800 periods, followed by *Al-Khwarizmi* d.850, Khiva among the West, *Al-Razi* d.925, Rhazes, Mas'ud d.957, *Abu Al-Wafa* d.997, *Al-Biruni* d.1050 and '*Umar al-Khayyam* d.1124. The Muslim Philosophers and Scientists appear to be in full control of the world stage of science for about three hundred and fifty years. They significantly contributed to human knowledge in various fields through their innovations. This contribution was so great that Islamic civilization has been the pioneer of the scientific, intellectual and cultural genius for a long period of time, with the West benefiting from its great achievements. Muslim scientists added vast areas to their territory. They could geographically expand the initial religious government which the Prophet had formed in Medina. Their government covered a large part of western Asia and northern Africa in addition to the Arabian Peninsula. They formed such a great government that within a short period of time most developed areas of the then civilized world were included in it. Muslims inherited the ancient civilizations and their heritage has dated back to the time of the Assyrians, the Babylonians, the Greeks, the Romans, the Iranians and the Egyptians. Being fascinated with sciences, Muslim Scientists acquired, assimilated and modified the rational and artistic heritage in cooperation with the scholastic figures of the very conquered lands. They also developed their specific culture and civilization [14].

The first and most forceful scientific and philosophical activities of the middle age from medicine

and mathematics to astronomy and alchemy were found in the territory of the Prophet [15]. In Spain, the Islamic civilization reached such a peak that in terms of scientific development, it was the honour of all cities around the world for three hundred years. The Islamic civilization had been shining in the present-day Spain. The Islamic civilization in Spain encompasses many fields that left a profound imprint in the Iberian Peninsula and Europe. The cultural climate of Spain in the era of Muslim rule (711-1492) brought about a prospering of different aspects of science and culture. The Impact of Arab math and science on Western civilization is evident in the scientific and mathematical language we use even today. Many scientific words in English derived from Arabic, like alchemy, algebra, al kalian, antimony, chemistry, elixir, zero, alcohol, algorithm, almanac, azimuth, cipher, sine, and zenith. In addition, many stars discovered by the Arab astronomers still bear Arabic names, for instance, the stars that comprises the tail of the constellation Cygnus is called *"Daneb"* the Arabic word of tail.

Contribution of Islamic Civilization to the Development of Science and Technology

Islam created of a world civilization in which people of many different ethnic backgrounds participated and played a central role in developing intellectual and cultural life. Islamic civilization played indelible roles to advancement of society as well as sciences, for instance, *Al-Harith b. Kaladah of Ta'if* d.634CE/14AH) known as 'Doctor of the Arabs' was the pioneer of Arab knowledge of science. It was the Arabs who injected the spirit of inquiry into Europeans. Muslim Scientists invented the numerical systems and algebra. Muhammad b. Musa, in the realm of Physics invented pendulum. The Muslim mathematicians such as Al-Khwarzimi, Muhammad b.Zakariya did not only pioneer the theory of algorism but also were the first to use decimal notion. Some chemicals were also discovered by Muslim Scientists. These chemicals in clued sulphuric acid, nitric acid, potassium, ammonia salt, alcohol, preparation of mercury. Ibn Zuhr known in Europe by Avenzoar introduced surgery as well as pharmacology in the 12th century. Abu Ali Husayn Ibn Zina known in Europe as Avicenna was regarded as the great physician. Indeed, his book *Magnum Opus* Al-Qanoon" served as a veritable material for several centuries especially in the European Universities. Abu Bakr Muhammad Al-Razi made his indelible print in the field of medicine. The Muslim Scientists developed original concepts in physics and chemistry, for instance, Al- Hazim had a pioneering work on optics. About twenty-one scientific discoveries invented by the early Muslim scientists. The contributions made by Muslims to the various branches of science, especially to mathematics and astronomy cannot be overlooked or ignored. From 9th to 13th centuries, Muslim Scientists were acknowledged as the world leaders in the development of the Arts and Sciences.

Muslim Scientists calculated the angle of the ecliptic, measure the size of the earth, calculated the possession of the Equinoxes and invented the pendulum clock, explained in the field of optics and physics, such phenomena as refraction of light, gravity, capillary attraction and twilight [16]. In the field of chemistry, Muslim scholarship led to the discovery of such substances as potash, alcohol, nitrate of silver, nitric acid sulphuric acid and mercury chloride. It also developed to a high degree of perfection the arts of textiles, ceramics and metallurgy.

Contribution of Muslim Scientists to the Various Streams of Modern Sciences

In Islam, nature is not seen as a separate entity, rather as an integral part of Islam's holistic outlook on God, humanity and the world. This link implies a sacred aspect to the pursuit of scientific knowledge by Muslims, as nature itself is viewed in the Qur'an as a compilation of signs pointing to the Divine. The Qur'an encourages it flowers for the acquisition of science and scientific knowledge. Not only this, it also urges humans to reflect on the natural phenomena as signs of God's creation. Some scientific instruments produced in classical times in the Islamic world were inscribed with Quranic citations. Arab Muslims became the touch bearers of science and learning. Islamic teaching encouraged and promoted the pursuit of scholarship and science. Seeking knowledge about the natural world was seen as the duty of every Muslim as the following Hadith sayings: *'He who pursues the road of knowledge, Allah will direct to the road of Paradis"* [17]. Muslim mathematicians were interested in number systems. They used two main systems of numerals: the *abjjad* system which used letters of the Arabic alphabet to represent numbers, and the Hindu-Arabic numerals which is now used in the West including zero. This replaced the awkward Roman numeral system in medieval times. They also borrowed a number system from the Babylonians which was based on 60, just like the minutes and seconds in our time system.

Astronomy

Astronomy may be the oldest natural science in the world. Before humans ever took to systematically studying the skies, we were craning our necks upwards, observing the curious movements of some bright points of light, and the stillness of others. Civilizations around the world have incorporated astronomical observations into everything from their architecture to their storytelling and while the pinnacle of the science is most commonly thought to have been during the Renaissance, While Europe was in an intellectual coma, the Islamic empire which stretched from Moorish Spain, to Egypt and even China, was entering their "Golden Age". Astronomy was of particular interest to Islamic scholars in Iran and Iraq and until this time around 800 AD. Muslim Scientists made significant contributions in the field of astronomy which is greatly

acknowledged in the history text [18]. Muslims have always had a special interest in astronomy. The moon and the sun are of vital importance in the daily life of every Muslim. By the moon, Muslims determine the beginning and the end of the months in their lunar calendar. By the sun the Muslims calculate the times for prayer and fasting. The math required for astronomy was also advanced in large part by Muslim Scientists. They developed spherical trigonometry and algebra, two forms of math fundamental to precise calculations of the stars.

1. **Ibn Yunus:** Ibn Yunus's full name is Abu'l-Hasan Ali ibn Abd al-Rahman ibn Ahmad ibn Yunus al-Sadafi. In the 10th century it was still believed that Earth was at the center of the universe. This discovery by Ibn Yunus and others like Ibn al-Shatir changed the landscape of astronomy forever. The heliocentric model eventually proposed by Copernicus in the 16th century was built on this body of work. Ibn Yunus's major work, an astronomical handbook was "*al-Zij al-Hakimi al-kabir*" 'Al-kabir" which means 'large'. The book is certainly large containing 81 chapters. There are lists of observations made by Yunus and also observations made by his predecessor [19].
2. **Abdur Rahman al-Sufi:** One of Iran's most famous astronomers Abdur Rahman al-Sufi published The Book of Fixed Stars, one of the most comprehensive texts on constellations in the sky. Abdur Rahman al-Sufi was also the first astronomer to observe the Andromeda galaxy and the Large Magellan Cloud. These observations would have been made purely with the naked eye since the telescope hadn't yet been created. He marked it down as a "cloud" in his notes. This work would later prove to be useful to famed Danish astronomer Tycho Brahe [20].
3. **Nasir al-Din al-Tusi:** In the 13th century, a Muslim scientists Nasir al-Din al-Tusi created the famous Tusi Couple. Tusi couple was able to demonstrate linear motion out of the opposing directions by placing a smaller circle within a larger one. The Tusi Couple would later become critical to Copernicus' understanding of these motions during his work in the Renaissance. Nasir Ad-Din At-Tusi was appointed a chief scientist at the observatory by Hulagu Khan, who was deeply impressed by At Tusi's knowledge, particularly astrological knowledge. Nasir Ad-Din At-Tusi produced astronomical tables called Ilkhanid Tables and a catalogue of fixed stars, which would be used for a few centuries around the world [21].
4. **Ibn al-Haytham:** One of most famous astronomers and scientific thinkers, Ibn al-Haytham is known as "the father of optics" because he was the first person to crack the code about how we perceive light. His work developed the camera obscure and eventually aided in the development of the telescope. The most significant contribution Ibn al-Haytham gave to the world was a methodical way of conducting experiments repeatedly in order to test a theory. This became known as the scientific method [22].
5. **Al-Battani:** Al-Battani was born in Harran ca. 859 in the present-day Turkey. His Latinized name is "Albategnius" [23] and his well-known discovery is the precise determination of the solar year as being 365 days, 5 hours, 46 minutes and 24 seconds. His outstanding observations of solar and lunar eclipses were used by Dethrone in 1749 to determine the secular acceleration of the Moon. Al-Battani wrote The Sabian tables named *al-Zij al-Sabi*, a very influential work for centuries after him [24]. Al-Battani discovered the notions of trigonometrically ratios used today.
6. **Al-Farghani:** Al-Farghani is a Persian astronomer born in modern-day Uzbekistan in a city later named after him *"Farghana"*. Al-Fargani's Latinized name is "Alfraganus" [25]. He determined the diameter of the Earth to be 6,500 miles and also calculated the diameters of planets. Al-Farghani created an Arabic summary of Ptolemy's *Almagest* around 833 and wrote *Elements of Astronomy* "*Kitab fi al-Harakat as-Samawiya wa Jawami Ilm an-Nujum*" which was translated into Latin in the 12th century. It was from this book that Dante derived the astronomical knowledge displayed in the "Vita Nuova" [26].

The work of the Muslim astronomers who lived between 9th and 12th centuries was both innovative and accurate. Many of the most basic concepts of modern astronomy were either developed directly by them, or came about through their influence on later astronomers.

Geography

Islam urged people to open their minds and horizons, and know about the wonders of God's creation and thus Muslim geographers ventured across the known and unknown world. Arab geographers were the most versed in the knowledge of paths, roads and routes. They determined routes on land and at sea with the help of stars. Some pieces of knowledge in astronomy helped them to determine the weather, time of sowing, etc. At the time of Abbasids, Muslim scholars took a keen interest in the shape of the Earth and everything on its surface. Thus, Caliph Abu Jafar al-Mansur ordered to translate some sciences, particularly astronomy, into Arabic. It was then that Claudius Ptolemy's book "Geography" was translated into Arabic at the request of Caliph al-Ma'mun [27]. This book was frequently referred to in the works of the great mathematician and astronomer al-Khwarizmi. His book "The Shape of the Earth" opened a new age in the geographical knowledge. In the 2-3 centuries AH, astronomy in the Islamic world gained a widespread development. Thus, in the 4th century AH, Muslim

scholars laid the foundation for a descriptive geography, which was based on the maps. Arab geographers were the most versed in the knowledge of paths, roads and routes. They were able to determine the precise distance of communication lines. Among these geographers are Ibn Hardazabah and Abu al-Faraj Ibn Jafar. "Al-Masalik wal-Mamalik", 'Roads and Provinces' written by Ibn Hardazabah is considered to be the first book in the school of Islamic geography. Among the earliest Muslim geographers were al-Khwarizmi, the mathematician, who participated in a project to draw a map of the known earth in the early 9th century CE. Al-Kindi, the philosopher, wrote an account of the inhabited parts of earth as known then. Some of the greatest traveler-geographers were Ibn Hawqal, who traveled for over 30 years and wrote about the places and people he saw, and the famous al-Mas'udi. He traveled, quoted geographic works that have disappeared, and wrote his own encyclopaedia of geography and history called *Meadows of Gold and Mines of Precious Stones* in 956 CE. The Muslims are considered as the forerunners of the modern concept of the philosophy of human geography.

1. **Ibn Hardazabah:** Ibn Hardazabah was a Persian by birth; he worked as chief of postal service in Maida, the mountainous province of Iran. He described in detail the sea routes leading to India and China, as well as to Central Asia, Byzantium and Andalusia. He described the culture, agriculture, plant and animal kingdoms of different countries [28].
2. **Abu al-Faraj:** Abu al-Faraj Kudamat Ibn Jafar headed the chancellery during the reign of al-Muktadir Billahi al-Abasi (272 AH). He travelled to all parts of the Abbasid Caliphate, using his knowledge of history, human activities, lines of communication. He wrote the book "Al-Haraj" which was constantly used by the Caliph to supervise the state of affairs in the Caliphate and to move troops to the desired location [29].
3. **Abul-Abbas Ahmad ibn Ya'qub Ibn Ja'far:** Abul-Abbas Ahmad Ibn Ya'qub Ibn Ja'far, known as al-Yaqubi. He made long journeys to Armenia, Iran, India, Egypt and Western countries. He wrote a book entitled "Al-Buldan" (Cities and Countries) is one of the earliest writings about geography [30].
4. **Abul-Hasan Ali Ibn al-Husayn al-Masudi:** Al-Mas'udi states that he was born in Baghdad and that he was a descendant of Abdullah Ibn Mas'ud, a companion of the Prophet Muhammad. He was an eminent geographer of the 4th century who travelled to the cities of the ancient world, from India to the Atlantic Ocean, and from the Red Sea to the Caspian. He also took journeys to Asia Minor and Iraq, and then settled in Egypt in 341 AH, where he died four years later. Among his books, the most famous ones are *"Marwaj az-Zahab"* 'The Place of Gold Sales' and *"Madin ul-Jawhar"* 'The Place of Jewelry Extraction' [31].
5. **Al-Bashari:** Shamsuddin Abu Abdullah Ibn Abi Bakrin al-Maksidi, also known as al- Bashari, is one of the most significant figures of the classical Islamic geography. He visited most of the Islamic countries and wrote a book *"Ahsan ut-Takasim fi Marifat il-Akalim"* 'The best way of regional division in terms of climate' [32].

The subject of Muslim Geography is vast and requires volumes to embrace. For the Muslims in Europe and America, the life and contributions of the famous geographer Al-Idris, who lived under Roger the second, is a good example of how Muslims in the western live and still contribute in a non-Islamic society.

Mathematics

One of the most-developed fields of science in Islamic civilization was Mathematics. Although the number system which is called Arabic has originally been developed in India and introduced in the Persian Gulf by Arab travellers. In mathematics, the Arabs adopted the concept of zero from the Indians, which enabled them to develop new areas of mathematics. Some mathematics processes retain their Arabic names today, such as *al-Jabr* which is now referred to as Algebra. Similarly, in chemistry words like "alcohol" and "*al kali*" are derived from their Arabic names *al-kahol* and *al-qaliy* respectively. The Muslim Scientists developed the symbol for zero and they systematized the numbers into the decimal system. They designed the symbol to precise an unknown quantity. Here we cite short biography of these wonder full Muslim scholars who contributed in the field of Mathematics as follows:

1. Muhammad bin Musa al-Khwarizmi: The first great Muslim mathematician, Muhammad bin Musa al-Khwarizmi, designed the subject of algebra which was supplementary advanced by others, most notably by Umar Khayyam. Al-Khwarizmi's work, in Latin translation, carried the Arabic numerals along with the mathematics to Europe, through Spain. The word "algorithm" is derived from his name. Al-Khwarizmi, born in 780 A.D., was the forefather of modern Algebra [33]. He developed sine, cosine and trigonometrically tables, which were later translated to the West. His book on algebra *"Hisab al-Jabr waal-Muqabalah"* (*The Calculation of Integration and Equation*) was used until the 16th century as the principal textbook of European universities. Al-Khwarizmi also aided to announce Arabic numerals, the decimal position system, and the concept of zero. Algebra and Algorithm are in fact corruptions of his work and name. Interestingly, this book on algebra comprised many examples from the Islamic inheritance laws and how they could be answered using algebra. Under al-Mamun, the caliph of the time, he with some others was the first to map the globe [34].

2. Ghiyath al-Din al- Kashani: Another exceptional mathematician was Ghiyath al-Din al-Kashani of the late fourteenth century. He functioned on the theory of numbers and techniques of computations [35]. One of his most important works was *"Miftah-ul-Hissab"* or *"The Calculators' Key"* in it he defined an algorithm for finding the fifth root of any number [36]. The book was taught in Persian schools until the seventeenth century. Later in his life he relocated to Samarkand on the invitation of the ruler to support directly to a new scientific school and observatory and conduct research with other scholars of the time. Kashani also wrote on how to approximate sin by solving a cubic equation accurately.

3. Abu Wafa Muhammad al-Buzanji: Abu Wafa Muhammad al-Buzanji was born in Buzjan, Nishapur in 940 A.D. He became a great mathematician and astronomer at Baghdad and died in 997 A.D. Al-Buzanji's main contribution lies in several divisions of mathematics, in geometry and trigonometry especially. In geometry he added to a solution of geometrical problems with opening of the compass, construction of a square equivalent to other squares, regular polyhedral, construction of regular hexagon taking for its side of the equilateral triangle inscribed in the same circle. Al-Buzanji's involvement to the progress of trigonometry was also widespread. He was the first person to show the generality of the sine theorem relative to spherical triangles [37]. He established a new scheme of assembling sine tables, the value of sin 30 being correct to the eight decimal places. In addition he deliberated tangent and planned tables for them. He announced the secant and cosecant for the first time [38]. He composed a large number of books on mathematics and other subjects, most of which have been lost or exist in modified forms. A substantial part of today's trigonometry can be copied back to him.

4. Abu Abdullah al- Battani: Abu Abdullah al-Battani (862-929 A.D.) was a son of a scientist and also a famous astronomer, mathematician and astrologer. He is often considered one of the greatest gastronomists of Islam. In mathematics, al-Battani was the first to substitute the practice of Greek chords and the first to cultivate the concept of cotangent and provided their table in degrees. He composed a number of books on astronomy and trigonometry. Al-Battānī's major work is *Kitāb az-Zīj* "Book of Astronomical Tables". It was largely based on Ptolemy's theory [39].

5. Mohammad Bin Ahmed: Mohammad Bin Ahmed in the tenth century invented the concept of zero or *Sifr*. Thus swapping the cumbersome, Roman numerals and creating a revolution in mathematics. This directed to improvements in the calculation of the program of the worlds and progresses in the fields of astronomy and geography [40].

6. Al-Hassan Ibn al-Haytham: Al-Haytham was a scientist who made major contributions to the fields of mathematics, physics and astronomy during the latter half of the tenth century. Al-Haytham played an important role in setting the scene in modern science. His work "*Kitab al-Manazir"* Book of Optics [41] interpreted a theory of vision and a theory of light and was called by his successors of the twelfth century "Ptolemy the Second". Al-Haytham wrote more than 200 works on a wide range of subjects. Most of his works are now lost, but more than 50 of them have survived to some extent. Nearly half of his surviving works are on mathematics, 23 of them are on astronomy, and 14 of them are on optics.

Muslim Mathematicians added not only to the use of logic in the development of mathematical ideas but also to an effective system of numeration that involved zero and headed to the solution of equations. Muslims had thus begun the work that directed on to mathematical modelling and its application for the purpose of testing their theories. The Arabs started work on arithmetic in the second half of eight century. Their first task in this field was to systematize the use of the Hindus minerals which are now permanently associated with their names. The rapid development in mathematics in the subsequent ages could not have taken place without the use of numerals, particularly zero without which all but the simplest calculations become too cumbersome.

Physics

In fact, The Natural sciences of Muslims commenced by relying on the publications of the Greeks who drew on mere philosophy in their attempt to understand nature without resorting to experimentation. However, Muslim scientists spared no efforts to develop this basis. They excelled in physics in an unprecedentedly subtle and intelligent fashion to the extent that they seemed to establish a new science. For example, they made physics rely on experimentation and induction rather than on philosophy, speculations, or mere thoughts. Muslim scientists studied acoustics, its origin and its transfer. They were the first to understand that sounds are affected by the bodies that cause them and that these sounds transfer in the air in the form of circular waves. Muslim scientists were also the first to categorize sounds into different types; they expounded that the sounds of animals differ according to the length of their necks, the width of their throats and the structure of their larynx. Muslim scientists were also the first to interpret the occurrence of echo as a reflection of the air which hits a high mountain or wall. The reflection of the echo cannot be realized due to the spatial closeness.

1. **Al-Haytham**: If there is an individual's name that is synonymous with the history of the development of physics, it has to be Al-Haytham‟s. Al-Haytham‟s involvement and contribution in the

science of physics, particularly in the area of optics, can be described as one of the fullest, from the establishment of the science of optics as a field by itself to the development of theories and having made remarkable contributions towards optics, he is also regarded as the father of modern optics. His book *"Kitab al-Manazir"* 'the optical thesaurus' is one of the leading classics which influenced scientific thought for more than six centuries. The*"Kitab Al-Manazir"* is more of an experimental and mathematical investigation on the properties of light that is related to vision, rather than a philosophical dissertation [42].

2. **Abual-Rihan Al-Beruni:** Al -Biruni is a renowned physicist, who determined the specific density of 18 types of precious stones. He established the rule which stated that the specific density of body suits the volume of the water which makes it move. He also interpreted the exit of water from geysers and artesian wells in light of the theory of communicating vessels. One of the most important of al-Biruni's many texts is Shadows which he is thought to have written around 1021. The contents of the work include the Arabic nomenclature of shade and shadows, strange phenomena involving shadows, gnomonic, the history of the tangent and secant functions, applications of the shadow functions to the astrolabe and to other instruments, shadow observations for the solution of various astronomical problems, and the shadow-determined times of Muslim prayers. Shadows are an extremely important source for our knowledge of the history of mathematics, astronomy, and physics. Topics in physics that were studied by al-Biruni comprised hydrostatics and made very accurate measurements of specific weights. He defined the ratios between the densities of gold, mercury, lead, silver, bronze, copper, brass, iron, and tin. Al-Biruni displayed the results as combinations of integers and numbers of the form 1/n, n = 2, 3, 4... 10 [43].

3. **Abu al-Fath Abd al-Rahman Mansour al-Khāzini:** Abuul Fath Al-Khazni was an incomparable physicist, particularly in relation with dynamics and hydrostatics to the extent that the succeeding researchers have been startled. His theories have been still calculated in the field on kinetics at schools and universities up till now. Among these theories are the Theory of Obliquity and Inclination and the Theory of Impulse. These two theories played an important role in kinetics. A lot of historians in the field of science regard Al-Khazani the physicist of all physicists. He dedicated most of his time to study hydrostatics; he developed a device to determine the specific gravity of liquids. He further studied the issue of resistance the body faced when it got into water. Al-Khazani operated the same apparatus used by his great master Al-Biruni to determine the specific gravity of some solid and liquid materials. The measurements of Al-Khazani were so accurate that they startled his contemporaries and successors. Al-Khazini pointed out that air had weight and power to boost things like air, adding that the weight of the object in the air weighs less than its actual weight and its condensed weight depends on the density of air. It is worth of note that these studies concreted the way for the inventions of the barometer, air vacuums and pumps among others. His best-known works are "The Book of the Balance of Wisdom" [44].

Chemistry

The Arabic word, *al-kimmiyâ* means quantity. It is to designate the science of chemistry. Chemistry is fundamentally based on experimentation with substances, turning one substance or matter into another by means of experimentation and laboratory work. This has been mainly the work of Muslims, and Muslims alone. The Muslims relied on experimentation. Such an approach was championed very early in particular by *Al-Razi*, who may be considered consequently the father of modern chemistry [45]. Although scientists such as al-Kindi and Ibn Sina's in his "*Kitab al-shifa*" 'the book of healing' devote some interest to the subject, and although there were tens of other Muslims who were involved in the science, there were primarily three Muslim chemists, truly masters of their science. These were in the chronology of their lives: Jabir, Al-Razi and al-Majriti.

1. Jabir ibn Hayyan: Jabir Ibn Hayyan was born in 702 A.D. He is known as Geber in western name, the father of modern chemistry and along with Zakariya Razi, who is the greatest name in the chemical science. The book "*Al Khawass al-kabir*" written by the Jabir Bin Hayyan was considered as the Bible of chemistry until the 18th century. He invented a kind of paper that resisted fire and an ink that could be read at night [46]. He also identified many new products, including alkaline, acids, salts, paints and greases. He prepared caustic soda and a multitude of salts such as sulphates. Some of Jabir's writings include *Al Khawass al-kabir*" "the Great Book of Chemical properties', "*al-Mawazin*", 'Weights and measures', "*Al-Mizaj"*, 'Chemical combination' and "*Al-Asbagh*", 'Dyes'. His influence may be traced throughout the whole historic course of European alchemy and chemistry and even in the modern chemistry.

2. Abu Bakr Muhammad ibn Zakariya al-Razi: He is known as Rhazes for the western world, was one of the most prolific Muslim doctors and probably second only to Ibn Sina in his accomplishments. He wrote more than 200 books, including "Kitab al-Mansuri" and "al-Hawi" an encyclopedia of medicine in 20 volumes. In his work *Secret of Secrets*, he made the very useful classification

of natural substances, dividing them into earthly, vegetable and animal substances. He added his remarks based on his experiments and observations. He classified substance in two categories; vegetable, animal or mineral, while the other alchemists divided substances into three categories; bodies, souls and spirits. Before he left chemistry for medicine, where he became one of the leading authorities, and occupied eminent functions in Baghdad as physician, he was also the founding father of truly modern chemistry. He was a pure rationalist, no nonsense scientist, who only believed in experimentation and concrete evidence, and never refrained from demolishing all previous speculative and erroneous conclusions, Al-Razi was interested in the medical uses of chemical compounds [47].

3. Abu al-Qasim al-Qurtubi al-Majriti: One of the Muslim chemist who deserve mention here is the Spanish Muslim court scientist al-Majriti from Madrid (950-1007). He was particularly noted for his work "*Rutbat Al-Hakim",* 'The Rank of the Wise' which amongst other things gives formulae and instructions for purification of precious metals. It was collected and put together in the year 1009, two years after his death. In this work, Al-Majriti was also the first to prove the principle of conservation of mass, credited eight centuries later to the French Lavoisier [48].

The science of Chemistry is unquestionably the invention of the Muslims. It is one of the great branches of science in which Muslims have made the greatest contributions and developed it to such a high degree of perfection that they are considered authorities in this science.

Pharmacology

In connection with chemistry, a large interest was devoted to pharmacology, in recent studies; this subject was examined in the context of Arabic chemistry. It was with this intermediary that several works of Muslim scholars were published and analyzed, such as al-Kindi's and al-Zahrawi's chemical investigation aiming at the creation of drugs [49]. The Muslims used in many ways the same methods, means and techniques in both chemistry and pharmacology to produce drugs. They prepared products they used for healing including camphor, alum, ambergris etc. Under Islamic civilization, this profession of pharmacist came into existence; the first shops were opened in the early 9th century in Baghdad. The Muslims were excellent organizers of knowledge, and so their pharmacological texts were directed carefully along the many directions which were either promising or useful to the apothecary and medical practitioner. These treatises as a result generally are more or less within well delineated groups. Some of the major types of Muslim pharmacological literatures are Sabur Ibn Sahl, Abu Mansur Muwaffaq, Al-Biruni and many more imminent Muslim pharmacologists who made a great contribution in this field.

1. **Sabur Ibn Sahl:** Sabur Ibn Sahl: (d 869) was the first physician to initiate pharmacopoeia, describing a large variety of drugs and remedies to ailments. In the 10th century, Abu Mansur Muwaffaq of Herat wrote "*The foundations of the true properties of Remedies*" where he described 585 drugs [50].
2. **Al-Biruni:** Al-Biruni (d. 1051) wrote one of the most valuable Islamic works on pharmacology entitled "*Kitab al-Saydanah"* 'The Book of Drugs' where he gave detailed knowledge of the properties of drugs and outlined the role of phar Biruni's most important work was a major *pharmacopoeia*, the "Kitab al-saydala fi al-tibb" (Book on the Pharmacopoeia of Medicine), describing essentially all the medicines known in his time.macy and the functions and duties of the pharmacist [51].
3. **Ibn Sina:** Popularly known as 'Avicenna', Ibn Sina was indeed a true polymath with his contributions ranging from medicine, psychology and pharmacology to geology, physics, astronomy, chemistry and philosophy. He was also a poet and an Islamic scholar and theologian. His most important contribution to medical science was his famous book al-Qanun, known as the "Canon" in the West. He described no less than 700 preparations, their properties, mode of action and their indications. He devoted in fact a whole volume to simple drugs in his *Canon [52]*.

As medical science developed, knowledge about pharmacology was systematically collected in written form. Pharmacologists working in the Islamic tradition were able to include drugs known to a wide variety of peoples. The Muslim pharmacologists developed this branch of modern science and made their immense contribution to cure the pain of the people by using different kinds of chemicals. They made science of pharmacology and compound cures, and set up the first pharmacies on the modern model.

Medicine

Medicine did not develop overnight. During the Dark Ages the medical flame was taken up by the Arabic-Islamic world. The period between the 7th and 13th centuries has been commonly neglected, despite the remarkable developments of biomedical science of the Arabic-Islamic world. At every stage in Arabic medical history we can find outstanding people whose greatest contributions and efforts cannot be underestimated. The increase use of dissection in Islamic medicine during the 12th and 13th centuries was influenced by the writings of the Islamic theologian, Al-Ghazali, who encouraged the study of anatomy and use of dissections as a method of gaining knowledge of God's creation.

The Arabic-Islamic world added much to earlier achievements in medicine. They fostered the flame of civilization, made it brighter and handed it over to Europe, This was solid inspiration to boost Muslim scientists to discover, progress, and spread over empirical laws. Ample considerations were specified to medicine and public health precaution. The very first hospital was constructed in Baghdad in 706 AC. The Muslims also used camel convoys as transportable hospitals, which stimulated from place to place. Ever since the religion did not prohibit it, Muslim scholars used human bodies to study anatomy and physiology and to support their students' realization on how the body works. This pragmatic study allowed surgery to mature very quickly. Medicine: Medicine is regarded as one of the extensive fields of life sciences to which Muslims had noticeable influences through their prosperous cultivation.

1. **Abu Ali Ibn Sina:** Abu Ali Ibn Sina (980-1037), better recognized to the West as Avicenna, was conceivably the utmost physician until the contemporary epoch. His renowned book "*Al-Qanun fi al-Tibb*" [53] stayed a typical textbook even in Europe for over 700 years. Ibn Sina's effort is still considered and assembled upon in the East. Other substantial offerings were made in pharmacology, such as Ibn Sina's "*Kitab al-Shifa"* (Book of Healing), and in public health. The Ottomans were particularly noted for their building of hospitals and for the high level of hygiene practiced in them. Every single city in the Islamic world had a number of outstanding hospitals and many of them were specialized for particular diseases, including mental and emotional. Abu Ali Ibn Sina, alone wrote 246 books, together with Kitab-al Shifa (*The Book of Healing*) containing 20 volumes and Al- Qanun fit Tibb (*The Canons of Medicine*). The *Qanun* was the principal guide for medical science in the West from the twelfth to the seventeenth century. Dr. William Osler, who wrote *The Evolution of Modern Science*, remarks "The Qanun has remained a medical Bible for a longer period than any other work" [54]. Ibn Sina's creative influences involved such developments such as acknowledgment of the communicable nature of phthisis and tuberculosis; spreading of diseases by water and soil and the collaboration between psychology and health. Also, the book defined over 760 medicines and became the most authentic of its era. Ibn Sina was also the first to describe meningitis and prepared ironic contributions to anatomy, gynaecology and child health.
2. **Abu Bakr Muhammad ibn Zakariya al-Razi:** Abu Bakr Muhammad ibn Zakariya al-Razi (865-925 AD) identified as Rhazes, was one of the greatest inexhaustible Muslim doctors and perhaps second only to Ibn Sina in his endeavours. He was born at Ray, Iran and became a student of Hunayn ibn Ishaq and later a student of Ali Ibn Rabban. He penned over 200 books, including *Kitab al-Mansuri*, ten volumes on Greek medicine, and *al-Hawi*, an compendium of medicine in 20 volumes. In *al-Hawi*, he encompassed every single medical subject's statistics offered from Greek and Arab sources and then added his clarifications based on his understanding and assessments [55]. He categorized substances as vegetable, animal or mineral while other alchemists divided them into "bodies", "souls" and "spirits". Al-Razi was first positioned in control of the first Royal Hospital at *Ray* from where he quickly moved to a similar position in Baghdad where he remained the head of its famous Hospital for a long time. He originated a treatment for kidney and bladder stones, and clarified the nature of various infectious diseases. He also accompanied research on smallpox and measles and was the first to announce the usage of alcohol for medical purposes.
3. **Abul Qasim al-Zahrawi:** A new physician who soon tracked al-Razi was Abul Qasim al-Zahrawi (963-1013 AD) who is recognized as *Albucasis* to the West. A renowned surgeon in his time, at the court of Caliph al- Hakam II, students and patients flocked to him from the Muslim world and Europe. He wrote the medical encyclopaedia "*al-Tasrif li man ajaz an-il-talif*" which enclosed 30 segments of surgical facts and drawings of 200 surgical tools, maximum of which he designed by himself [56]. The Encyclopaedia was not only a typical one for physicians, but even five eras later it was being used as the standard textbook on surgery in universities in Europe. He also accomplished many elusive operations such as Caesareans and was also the first to use silk thread for sewing wounds. pointed out that good practice in surgery requires a sound knowledge of anatomy [57].
4. **Al -Idrisi:** Al-Idrisi was born in Cordova, Spain in 1099. His major involvement was in medicinal plants which he labelled in many books, such as "*Kitab al-Jami-li-Sifat Ashtat al-Nabatat*" [58]. He composed plants and data not described previously and compiled this to the subject of botany. From him a large number of new medicines from plants with their assessments suited to medical doctors. Al-Idrisi also prepared unique assistances to topography, as connected to economics, physical factors and cultural aspects. He penned geographical encyclopaedias, the largest called "*Rawd-Unnas wa Nuzhalat Nafs"* 'Pleasure of Men and Delight of Souls' [59]. Al-Idrisi also inscribed on the themes of fauna, zoology and therapeutically features. His work was soon translated into Latin and his books on geography especially stayed famous in the East and West for more than a few spans.
5. **Abu Muhammad Ibn al-Baitar:** Abu Muhammad Ibn al-Baitar was working in the field of botany

also from Spain. He was one of the paramount scientists of Muslim from Spain and one of the chief botanists and pharmacists of the middle Ages. He travelled on many wandering voyages to gather plants as far as Africa and Asia. He composed "*Kitab al-Jami al-Adiwaya al-Mufrada*" one of the supreme botanical accumulations allocating with medicinal plants in Arabic [60]. The encyclopaedia was completed of over 1,400 items, many of which were not known before. The book discussed to the works of 150 authors, mostly Arabic and cited about 20 early Greek scientists. It was translated into Latin and printed as late as 1758. Ibn al-Baitar's works were categorized by thoughts, investigation and classification and exercised a profound influence on Eastern as well as Western botany and medicine [61]. Even though many of his works were translated and published late in the western languages. Many earlier scientists had deliberated numerous portions of his books and quoted a number of references to it.

Medicine is regarded as one of the extensive fields of life sciences to which Muslims had noticeable influences through their prosperous cultivation. These assistances were unprecedentedly comprehensive, divergent, and educative to the amount that the spectator of these everlasting influences may have faith in that medicine had not be present earlier to the advancement of Muslims.

CONCLUSION

Nature is not seen as a separate entity in Islam, rather it is an integral part of Islam's holistic outlook on God. This link implies a sacred aspect to the pursuit of scientific knowledge by Muslims. The Contribution of Islamic civilization to science and technology from the 8th to 16th century is a noteworthy expansion in human antiquity. The Muslim scientists not only conserved the ancient knowledge, but also they transformed it into major new contributions to the basic science and technology. The basic contributions were in fields as such; astronomy, chemistry, mathematics, philosophy, geography, and physics, which constitute the basis of modern science and technologies. Muslims scientists significantly contributed to human knowledge in various fields through their innovations. Muslim mathematicians had inborn both the Babylonian hexadecimal system and the Indian decimal system, and this provided the basis for numerical techniques in mathematic. Muslim scientists constructed mathematical models using the decimal system, conveying all numbers by means of ten symbols, and each symbol permitted the value of position as well as absolute value. Many inventive methods of doing multiplications were established by Muslims; methods of checking by casting out nines, and decimal fractions. Hence, Muslim Scientists added and positioned the foundations of modern mathematics and the use of mathematics in the fields of science and engineering. This contribution was so great that Islamic civilization has been the pioneer of the scientific, intellectual and cultural genius for a long period of time, with the West benefiting from its great achievements. Muslim intellectuals became references to the world. For more than five centuries, the Islamic civilization remained the basic source of science, technology and prosperity.

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