

# CONTRIBUTIONS OF MUSLIM PHYSICIANS AND OTHER SCHOLARS DURING THE 8<sup>TH</sup> THROUGH THE 14<sup>TH</sup> CENTURY AD

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## Introduction

Prior to the advent of Islam, the Arabic society was uncivilized, ignorant, barbarous, and they showed little interest in intellectual matters. Quran was revealed to Prophet Muhammed in years 612-632 as a book of guidance, and this had a profound effect on the Arabic society. The first revelation of the Quran inspired the Prophet of Islam to acquire knowledge and emphasized the importance of learning in human life. The Quran repeatedly urges mankind to understand the forces of nature for the benefit of man and his intellectual growth, and it brought to humanity the interest in scientific thinking. “Your Rabb is the most Gracious Who taught by the pen, taught man what he knew not.” (96:3-5) <sup>Malik (1997)</sup> The Quran makes it clear that all that is in the heaven and in the earth has been made subservient to human beings, the viceregent of Allah. Allah has endowed human beings with the capacity to use their intellect to reflect upon things, and to express their ideas by speech, and in writing. (55:1-4) <sup>Ali (1989)</sup> Muslims are encouraged by the commandments of the Quran and Prophetic sayings to seek knowledge, and study nature to see the signs of the Creator, which thus inspires human intellectual growth. This was the major reason why Muslims have made contributions to scientific development. In another verse the Quran emphasizes upon the reader to think, investigate, and find out the mysteries of the world. “Do they not look at the camels, how they were created? The heaven, how it was raised high? The mountains, how they were firmly set? And the earth, how it was spread out? So keep on giving admonition, for you are an admonisher...” (88:17-21) <sup>Malik (1997)</sup> Quranic verses encourage man to reflect (think) and understand the nature He created. “In the earth there are tracks side by side, gardens of grapes, corn fields, and palm trees; with single and double trunks. They are all

watered with the same water, yet we make some of them excel others in taste. Surely in this there are signs for people who use their common sense.” (13:4) <sup>Malik (1997)</sup> There are hundreds of similar verses in the Quran which describe mysteries of the universe and stimulate human thinking towards understanding and exploring the laws of nature. Quran emphasizes the need for observation of natural processes and reflects on what He has observed. No verse in the Quran contradicts scientific data. Thus, theology, philosophy, and science are finally harmonized through Islam’s ability to reconcile religion and science. <sup>Lande (1988)</sup> According to the sayings of Prophet Muhammed (PBUH), “there is no illness without a cure” and since Allah has created a cure for all diseases except old age, it is necessary for the scientists to search for the cure of the diseases through advances in medical treatment. Few of the several prophetic traditions such as: “The search for knowledge is obligatory on every Muslim or Muslimah.” “The ink of Scholars is worth more than the blood of martyrs,” “He who adores knowledge, adores God,” “Wisdom is the goal of all believers, acquire it from anyone,” “Whoever wishes to have the benefit of this world, let him acquire knowledge. Whoever wishes to have the benefit of the world hereafter, let him acquire knowledge” further emphasize the importance of seeking knowledge. <sup>Nadvi</sup> Prophet Muhammed further pointed out that only the learned will inherit his legacy, and will be the trustees on Allah on earth. He is said to have encouraged Muslims to go over to China if necessary in search of knowledge. Muslims should not regard the worldly sciences as discouraged or forbidden. When Prophet says: “Who goes in search of knowledge, he is in the path of Allah till he returns” and “Allah makes easy the path of Paradise to him who journeys for the sake of knowledge.” <sup>Khan (1997)</sup> Obviously, when the Prophet emphasizes going out to seek knowledge, he is not referring to the knowledge of Quran and Shariah only, which was readily available in Mecca and Medina. Therefore, Muslims during the early period of Islam had a better

and deeper understanding of Quran and Prophetic guidance and took upon themselves to go all over the world to seek knowledge, and establish fine institutions of learning throughout the Muslim world. The new methods of experimentation, observation, and measurement on which modern science is based are all contributions of those who followed the true teachings of Islam.

Mirza (1986)

The pre-Islamic Arabs had limited knowledge of physical and experimental sciences. It was after the conquest of Egypt and some territories of the Byzantine Empire that the Muslims came across some scientific institutions in Jundaishapura, Harran, and Alexandria. They discovered the scientific and philosophical work of the Greeks in these places that raised curiosity and the desire to acquire knowledge. <sup>Saud (1994)</sup> The period between the eighth and the fourteen centuries is regarded as the Golden period in Muslim history during which the Muslims established the most powerful empire and produced the most brilliant scientists and scholars of that time. The Muslim scholars such as Ibn-Sina, Al-Khawarizmi, Ibn-Razi, Zahrawi, Al-Biruni, Ibn Haytham, Al-Idris, Al-Kindi, Ibn-Khaldun and hundreds of other Muslim scientists made their observations and original research and added a vast treasure of scientific knowledge in the field of mathematics, medial sciences, astronomy, geography, economics and philosophy. The contribution of Muslim scientists and scholars show the highest quality of scientific development during that period. Muslim scientists were spread throughout the Muslim empire from Bukhara (Uzbekistan) in the east to Baghdad (Iraq), Isfahan (Iran) and Cordoba (Andalusia- Spain) in the West. They established universities and learning centers that attracted students from all over the world. Cordoba in Andalusia (Spain) alone contained 17 universities, 70 public libraries and hundreds of thousands of books for students. <sup>Abercrombie (1988)</sup>

Muslim scholars, under the guidance of the Quran and Sunnah that encouraged scientific exploration of the world as a form of worship, produced excellent scientific and other scholarly works that eventually had a profound influence on western thought, and western civilization,. This was during the time of the West's "Dark Ages" in which the entire intellectualism of the church dogma suppressed scientific progress. The church opposed freedom of thinking, and even a great scientist such as Galileo was punished due to his theory that the world rotates around the sun, which clashed with the church's dogma. For a thousand years, the scientific, medical, and scholarly work had virtually stopped in Europe. Most of the work done by Greek and some Roman scholars remained dormant. The burning of the great library of Alexandria in 390 A.D. by fundamentalist Christians had already resulted in the loss of valuable works. <sup>Whitty (1999)</sup>

Unfortunately, the West has continuously suppressed and downplayed the contributions of Muslim scientists. Most books and articles on the history of medicine and the sciences outline the contribution of Greek scientists that is usually followed by scientific progress since the Renaissance. Students are taught that Christian European scientists made all the scientific advances after the original Greek contributions. The scholarly work of Muslim scientists is rarely acknowledged in major publications of medical and scientific works in the West. Morowitz, a historian, described this phenomenon of concealment as "History's Black Hole." "This is [a] myth that gives a distorted view by giving the impression that [the] Renaissance arose Pheonix-like from ashes, smoldering for a millennium of classical age of Greece and Rome." <sup>Morowitz (1992)</sup>

Nevertheless, a number of distinguished historians and scientific investigators (like John Williams, EA Myers, Max Meyerhof, Philip K.Hitti, George Sarton, M. Ullman, EG Brown and Savage Smith) have fully acknowledged the part played by medieval Muslim scientists not only in preserving the knowledge of Ancient Greece, Persia and India, but also adding original

contributions to the wealth of knowledge. <sup>Brown (1962), Hamdani (1962), Ullman (1978), Savage (1994), Sarton (1947)-I,</sup>

<sup>Myers (1964), Hitti (1964)</sup> Bernard Lewis further clarifies in his book on Middle East that Islamic scientific development was not solely dependent on ancient Greek knowledge. He wrote: “the achievement of medieval Islamic science to the preservation of Greek learning, nor to the incorporation in the corpus of elements from the more ancient and more distant East. This heritage which medieval Islamic scientists handed on to the modern world was immensely enriched by their own efforts and contributions. Greek science on the whole rather tended to be speculative and theoretical. Medieval Middle Eastern science was much more practical and in such fields as medicine, chemistry, astronomy, and agronomy, the classical heritage was clarified and supplemented by the experiments and observations of the medieval Middle East.” <sup>Lewis (1998)</sup>

The output, originality, and creativity in science and technology in the Muslim world continued until about the 16<sup>th</sup> century. During this period, the Muslim scientific and scholarly work gradually spread to Europe. <sup>Nasr (1976)</sup> Sicily and Spain were the principal sources of such dissemination. From Spain the knowledge penetrated beyond the Pyrenees into Western and Southwestern France and Sicily. The Christian ruler Roger II was instrumental in transferring the Muslim scientific contributions and culture through Italy across the Alps to various European cities that became centers of Arab learning.

This article aims to contribute to a more accurate understanding of the history of medicine and the sciences, by focusing on the contributions Muslim scientists made during this era of the Muslim “Golden Age.”

Within two centuries after the death of Prophet Muhammed, the Muslims conquered new lands, their empire extended from India in the East to Spain in the West, and included Arabia, Syria, Egypt, Iraq, North Africa, Iran, and Turkey. These isolated nations now became part of the

Muslim empire. As a result of this, Muslims were introduced to different languages and scientific technological advances from various civilizations of the world. Muslim scholars and businessmen traveled to other distant places, like India and China, and brought back knowledge with them. In addition to a geographical unity of Asian, African, and European countries, the Arabic language became an international language facilitating communications across different cultures and regions and it also became a language of science and technology.

Islam's tolerance and encouragement of both secular and religious learning, created the necessary climate for the free exchange and propagation of ideas and knowledge. Baghdad (Iraq) and Cordoba (Spain) became the world's greatest learning and teaching centers. All available scientific work on mathematics, philosophy, medicine, and astronomy were translated from Greek, Roman, Indian, Persian, and Syriac languages into Arabic. The Abbasid Caliphs who were recognized for their pursuit of knowledge and support of academics, established the *Baitul-Hikmah* (House of Wisdom) and sent emissaries to various parts of the world, including the Byzantine Empire, to collect scientific manuscripts. Caliph Al Mamun established a school of translation and appointed Hunan Ibn. Ishaq, a Christian, as the director who was a gifted translator and scientist. Hunan Ibn Ishaq did major translations of the entire works of Aristotle, Hypocrites and Galen into Arabic. The *Baitul Hikmah* had a long-lasting influence on mathematics, economics, astronomy and philosophy, chemistry, and the medical sciences. It produced famous Muslim thinkers like Al Kindi and Al Farabi. Caliph Al Mutadad (9<sup>th</sup> century) patronized another scholar Thabit Ibn Qurrah (a Sabian) who translated and published commentaries on the works of famous Greek scientists and philosophers and published some original work on mathematics, astronomy and philosophy. Sinan, son of Thabit Ibn Qurrah became the Director of several hospitals (Bimaristans) in Baghdad.

The Spanish Umayyad Caliphs' liberal support for academic work also played a significant role in producing original scientific works. "The world is held up by four pillars: the wisdom of the learned, the justice of the great, the prayers of the righteous, and the valor of the brave" was the inscription often found around the entrance of the universities in Spain during the Muslim era. <sup>Abercrombia (1988)</sup> In Spain, the involvement of non-Muslim scholars in the scientific enterprises also shows the admirable quality of interfaith tolerance and cooperation of Umayyad Caliphs.

Commenting on the rise of Islamic civilization and its policy of tolerance towards people of all faiths, John Esposito pointed out: "The genesis of Islamic civilization was indeed a collaborative effort, incorporating the learning and wisdom of many cultures and languages. As in government administration, Christians and Jews who had been the intellectual and bureaucratic backbone of the Persian and Byzantine empires participated in the process as well as Muslims. This ecumenical effort was evident in Caliph Al Mamun's reign. The House of Wisdom's translation center was headed by the renowned scholar, Hunayn Ibn Isaac, a Nestorian Christian. This period of translation was followed by one of Muslim intellectual and artistic activity. Muslims ceased to be disciples and became masters, in the process of producing Islamic civilization dominated by the Arabic language and Islam's view of life." <sup>Esposito (1998)</sup> Unfortunately, this aspect of Islamic tolerance is not recognized in the West today.

The Arabic translations of important treatises from Greek, Indian and other pre-Islamic civilizations preserved precious work for thousands of years and prevented it from extinction. Many translations, along with Arabic commentaries were translated again into Latin and reintroduced in Europe. These translations and the original contributions of Muslim scientists and scholars became the foundation of modern medical and other sciences. <sup>Nadvi</sup> Muslim

physicians established medical schools in Baghdad and Cordoba where students from the Middle East and Europe came to study. The European medical schools of Montpellier, Padua and Pisa were founded on the pattern of Muslim medical schools in Cordoba. The medical encyclopedic work, 'al-Qanun' of Ibn-Sina (The Canon of Avicenna), and the surgery books of Abul Qasim al Zahrawi remained the textbooks of medical sciences throughout Europe, until the 16<sup>th</sup> century, when European works came to replace these texts. <sup>Briffault (1928)</sup>

Greek scientists were excellent in theorizing and formulating hypotheses. They were great observers, but not experimentalists. Greek literature did not show any documentation of experiments. Muslim scientists, for the first time, introduced the concept of the recording of data based on both observations and experimentations. The Greeks had a strong belief that Aristotle and Plato's opinions were final and there was no possibility of mistakes in their views, although they were only theorizing and attempting to explain various phenomena to the best of the capabilities of their speculative knowledge. <sup>Whitty (1999)</sup> As Briffault wrote, "Science owes a great deal more to the Arab culture, it owes its existence to Arab scientists, who made startling discoveries and revolutionary theories. The Greeks systematized, generalized, and theorized, but the patient ways of investigation, the accumulation of positive knowledge, the minute methods of science, detailed, prolonged observation, and experimental inquiry were introduced to the European world by Arabs only." <sup>Briffault (1928)</sup>

I turn now to elaborating on some more specific contributions from the field of medicine, chemistry, pharmacology, mathematics, astronomy, geography, political science, sociology, philosophy and technology.

**Medical sciences-** The major well-researched scientific progress in medicine was made between the 8<sup>th</sup> and 11<sup>th</sup> centuries during the era of Umayyad and Abbasid Caliphates. Muslims became



acquainted with Greek anatomical descriptions, and through their own research, found many errors in their work. For instance, in opposition to Galen, who thought that the human skull consisted of seven bones, the Muslim scholars held that it had eight. They also found that there were ossicles in the ear, which facilitate the hearing capacity. <sup>Wasti (1962)</sup> Yuhana Ibn Masswayh dissected a monkey to get more information about the human body. Al-Zahrwai emphasized that knowledge of anatomy is necessary to become a surgeon.

During the 9<sup>th</sup>-12<sup>th</sup> centuries, many great hospitals were built. These hospitals were called “Bimaristan” (Bimar - sick, stan -a place to stay). They were well-organized institutions based on the principles of human dignity, honor and hygiene. They were well administered by competent physicians, and also served as Teaching Hospitals and Research Institutions. Many famous Muslim physicians were associated with these hospitals. One of the early hospitals, Muqtadi was founded in Baghdad in 916 under the direction of a famous physician, Al-Razi. This hospital retained several physicians on the staff, including specialists like surgeons, and bone-setters (orthopedic surgeons). The development of these hospitals was an outstanding contribution of Muslim physicians. The hospitals served all citizens free of charge and irrespective of race or religion. There were separate units for male and female patients, and special wards for medical diseases, contagious diseases, and psychiatric patients. The physicians and nursing staff were licensed to assure quality of care. Libraries were also affiliated with the hospitals that were frequently used by students and teachers. It is recorded that these hospitals were furnished like palaces. Ibn Jubayr, the renowned Arab traveler described the care for the patients in Muqtadi Hospital as follows: “In this hospital, best arrangements exist for providing medical aid. The patients are dealt with very courteously and sympathetically. All patients are given food and care freely. For meeting the sanitary requirements, the water of Tigris is supplied

through pipes. Every Monday and Thursday eminent medical consultants visit this hospital and assist the regular staff in diagnosing complicated and chronic diseases, and suggesting their treatment. In addition, medical attendants prepare food and medicine for every patient under the guidance of the medical men treating him.” Wasti (1986)

In major cities like Baghdad, the mentally ill were treated in separate hospitals. The first known hospital for the mentally ill was built in the 10<sup>th</sup> century in Baghdad (Iraq), and later in Damascus (Syria). The mentally ill patients were treated with kindness and dignity, and their suffering was recognized as part of the illness. This was the period when the mentally ill were regarded as ‘witches’ and ‘possessed’ in Europe, and some of them were burned alive. Contrary to this, the mentally ill patients in hospitals of Baghdad received medications and support services. It was not until 1793 that Philippe Pinel introduced humane treatment for the mentally ill in France, which was adopted in Europe at a later date.

Muslims physicians initiated the regulating of the medical practice through the licensing of physicians and pharmacologists. Similar rules were later established in Sicily, when Roger II, King of Sicily (1095 – 1154), established the requirement of passing an examination before a physician could start practicing medicine. Thus the requirement of licensing began in Europe through Italy, then Spain and France.

Through the European medical schools at Montpellier and Salerone, the vast medical knowledge was passed on to Europe. The *Pharmacopoeia* of the London College of Physician (1618), a classic work systematizing drugs, recognized this debt to Muslim (and Greek) physicians as it was illustrated with portraits of the few great scholars: Hypocrites; Galen; Avicenna (Ibn Sina); and Mesue (Ibn Zakriya bin Masawaih). Whitty (1999)

Muslim surgeons developed a number of surgical techniques that were extremely advanced, especially in eye surgery. They used cauterization extensively in surgery, and described a variety of illnesses that were treated by cauterization. Ibn Zuhr (12<sup>th</sup> century) described the operation of a tracheotomy and Al-Zahrawi (10<sup>th</sup> century) invented many surgical instruments, such as instruments of internal examination of inner ear, inspection of urethra, and an instrument for the removal of foreign bodies from the throat. His books of surgery contained the picture of all surgical instruments he was using. Muslim physicians also made use of anesthetic substances while performing operations.

Muslim physicians were the first to write medical textbooks in a format that medical students could use in their learning. These textbooks were based on original Greek and other existing works and also new scientific data gathered by the Muslim physicians. The most famous medical scholarly works were produced by Al Razi (Rhazes- 932), Al-Zahrawi (Albucasis- 1013) and Ibn Sina (Avicenna-1092). Al Razi was the first physician who described how to differentiate between measles and smallpox. He also discussed the treatment of various ailments by dietary restrictions and regulations. After several centuries, we are once again including dietary regulations as the most important part of treatment of some severe illnesses like diabetes, hypertension and heart disease. Al Razi's textbooks were translated into Latin and used in European medical schools until the 16<sup>th</sup> century. Ibn Sina's encyclopedic work- "Qanun Fil Tib" surveyed the entire medical knowledge available from ancient and Muslim sources. He also documented his original contributions such as the recognition of the contagious nature of Pthisis and tuberculosis, and the spread of diseases through water and soil. His books contained the authentic record of 760 drugs that were in use. His books were translated and used as textbooks for medicine for several centuries in Europe.

Al-Razi along with Ibn Sina described the different parts of the eye and noted that the movement of the eyeball was caused by contractions of eye muscles, and pupillary movements were caused by contractions and expansions of the iris. Muslim surgeons also performed operations for the removal of cataracts. Ibn Haiytham's (956-1038) most important contribution was giving a correct concept of the process of visual perception. He was the first to prove that rays passed from objects towards the eyes, not vice versa which was the prevalent belief postulated by Euclid and Ptolemy. He also described that the impressions of objects made upon the eye are conveyed along the optic nerve to the brain, culminating in the formation of visual images. <sup>Wasti (1962), Ali (1999)</sup>

Abul Qasim Al-Zahrawi was born in Cordoba, in 936 and is considered the greatest surgeon whose comprehensive medical text combining Eastern and classical teachings shaped European surgical procedures until the Renaissance. He wrote famous books: 'Al-Tasreef' in 30 volumes, which contained the work of previous surgeons, and his own surgical procedures. The last part of the book containing drawings of more than 200 instruments that constitute the first illustrated independent work on surgery. His books remain the leading book of surgery for 500 years in Europe. <sup>Encycl. Brit. (1983)</sup>

Muslim physicians described the anatomy of the lung and bronchi and the interactions between the human body's blood in vessels and air in the lungs. Ibn Nafees (1213-1288) was the first to describe about the two circulatory systems, namely Aortic, and Pulmonary, three centuries before Harvey's discovery. He also elaborated on the function of coronary arteries in supplying the heart muscle.

**Chemistry-** Muslims developed chemistry as a distinct branch of science, and the word 'chemistry' is derived from the Arabic word: "Al chemya." It needs to be pointed out that

Muslim scientists who pioneer the work in chemistry are often called Al-chemists, and sometimes Al Chemya is associated with a pseudo-science of transmutation of the base metal into gold. “Al” in Arabic means ‘the,’ and “chemya” means chemistry. Therefore, the word: “Al chemya” means ‘the chemistry’ and should not be associated with pseudo sciences. <sup>Muslim Cont.</sup>

Chemistry (2003) The most notable Muslim scientists opposed the false notion that ordinary metals can be changed to gold by a chemical process. The 8th century Muslim scientist from Iraq, Jabir bin Hayyan (Geber), is known as the Father of Chemistry. He is the first scientist to introduce experimental investigation (*tajribah*) into chemistry by perfecting techniques of crystallization, distillation, sublimation, evaporation, and he developed several instruments to perform the tests. He discovered several minerals and acids that he prepared for the first time. Jabir described three distinct types of substances: spirit, those that vaporize with heat as camphor and ammonium chloride; metals such as gold, silver, and iron; and compounds which can be converted into powder. He has written over 2000 papers on his experimental work. Jabir bin Hayyan advised his students not to accept anything as true until they examined it themselves. “The most important task of the Al Chemist is to do practical work and to carry out experiments. Without practical application and experiment, nothing can be achieved.” <sup>Khan (1997)</sup>

David Tschnaz stated that Jabir’s works on Al Chemy (Chemistry) were translated into Latin and made their way into Europe, and for centuries, they served as the ultimate authority to European scientists including Arnold of Villanova (1240-1313), Roger Bacon (1214-1294) and Albert Magnus (1193-1280). In this process, many of the basic terms of chemistry and pharmacology, eg: Alkali syrup, julep, and alchemy (chemia) itself were introduced with European languages-a testimony to the wide-ranging contribution of these early Arab scientists.

Tschnaz (2001)

Al-Razi, one of the greatest Muslim physicians of the 9<sup>th</sup> century was also a brilliant chemist who continued his work on chemistry while practicing as a physician. He refined the processes of distillation and sublimation. He introduced mercurial compounds for the treatment of various ailments. Ibn-Sina, another brilliant scientist, also adopted Ibn-Jabir's methods for chemical experimentation, and used them as basis for determination of the efficacy of new pharmaceuticals.

Gustave Le Bon, the French Orientalist, attributes modern European chemistry to Muslim scientists: "It must be remembered that no signs, either, of chemistry, or any other science, was discovered all of a sudden. The Arabs had established 1,000 years ago their laboratories in which they used to conduct scientific experiments and publish their discoveries without which Lavoisier (called The father of chemistry) would not have been able to produce anything in this field. It can be said without the fear of contradiction, that owing to researches and experiments by Muslim Scientists, modern chemistry came into being, and that it produced great results in the form of great scientific inventions." <sup>Zahur (2000)</sup>

**Pharmacology-** Muslim physicians also made the most significant contribution in pharmacology. They not only discovered many herbal drugs but also perfected many of the techniques of chemical extraction, including distillation, sublimation, filtration, coagulation, and crystallization due to their expertise in chemistry. Al-Zahrawi (936-1035), a prominent surgeon who was very skilled in the use of simple and compound remedies, was known as a pharmacist surgeon. The 13<sup>th</sup> century Muslim Spanish scientist, Al-Baitar visited Africa, India and Europe and collected samples of plants through extensive field studies. He classified plants by their characteristics in alphabetical order and therapeutic qualities. He also wrote Arabic, Roman and Berber names of the plants and gave information about the preparation of drugs and its

administration. He discovered, and documented 200 new plants that were not known previously. His famous book “Kitabel Jami Fil Advia Mufradat,” (A compendium of simple drugs and foods) was translated into Latin and was used in the formulation of the first London Pharmacopoeia issued by the College of Physicians during the reign of King James I. <sup>Lande (1988), Ashoor (1984), Khan (1982)</sup> According to Levey, the Muslims were expert organizers of knowledge, and their pharmacological texts directed carefully along lines that were useful to the apothecary and medical practitioner. <sup>Levey (1973)</sup>

**Mathematics-** Muslims made numerous discoveries in the field of mathematics, which have been passed on to modern science, contributing to the technological revolution that sprang up in early modern Europe. One of the most notable of these innovations was to pass on the concept of zero. Al-Khwarizmi, a Persian scholar living in the ninth century was appointed as a scientist in Bait-ul-Hikmah of Baghdad by the Caliph. He developed the concept of Algorithms – a way of calculating -which bears the Anglo-cized version of its inventor’s name. His work in Algebra was outstanding, as he gave analytical solutions of linear and quadratic equations which established him as the Father of Algebra. The word ‘algebra’ is derived from his famous book, “Al Jabr wa al Muqabalah” (the compendious book on calculation by completion and balancing). The book contained the most important of al-Khwarizmi’s work. This work is generally considered the first to have been written on the subject. Al-Khwarizmi also learned the concept of zero from India, and through his works it was transmitted to Europe. The Indians had left a blank for a zero, and al-Khararizmi’s addition was to give it a symbol, the “0.” Even the English word ‘zero’ is derived from the Arabic name for this symbol “*sifr*.” Leonardo Di Vinci studied the Arabic numeral system and introduced it to Europe. <sup>Saud (1994)</sup>

Abul Wafa- Al-Buzjani (940-997) developed trigonometry. He was the first person to show the generality of the Sine theorem relative to spherical triangles. <sup>Sarton (1947)-II</sup> Al-Tusi, another Muslim scientist of the 13<sup>th</sup> century developed the subject of spherical trigonometry including 6 fundamental formulas for the solution of spherical, right-angled triangles.

**Astronomy-** A Muslim astronomer of the 10<sup>th</sup> century, Al-Battani made several original contributions in the field of astronomy. He determined the solar year as being of 365 days, 4 hrs and 46 minutes. He proposed a new and ingenious theory to determine the condition of visibility of the new moon. European astronomers used his observations of solar eclipses in 1749 to determine the acceleration of motion of the moon.

Muslims invented the compass and Al-Fargani (860) estimated the circumference of the earth to be 24000 miles. <sup>Salam</sup> Muslims were the first to use the pendulum, build observatories, catalogue the maps of the visible stars, and correct the sun and moon tables. They also wrote about sunspots, eclipses, and comets. Muslim scientists made a distinction between astronomy and astrology, and regarded astrology as a pseudoscientific subject. The 13<sup>th</sup> century Muslim astronomer, Al-Tusi earned his fame by producing astronomical tables called Al-Zij-Ilkhani, which became the most popular tables among astronomers. He pointed out several serious shortcomings in Ptolemy's astronomy, and foreshadowed the later dissatisfaction with the system that culminated in the Copernican reforms. In the 10<sup>th</sup> century, Muslims built an observatory in Baghdad and the famous Samarkand observatory was built in the 13<sup>th</sup> century when Tusi worked on the measurements of planetary movements. Ibn Shaitor of Damascus (14<sup>th</sup> century) continued the work on planetary movements, using a combination of perfect circulatory motions. The famous European astronomer Copernicus was familiar with Ibn Shaitar's work and used his



theories to suggest heliocentric system of movements of planets, as opposed to the geocentric system of Ptolemy. <sup>Sayeed (2000)</sup>

**Geography-** Al-Masudi, a 10th century Muslim geographer and historian, traveled to Baghdad, India, China and several other countries of the world. He described his experiences of various countries, people, climates, and the geography and history of countries he had visited. He documented historical events chronologically. He wrote 34 books covering a variety of these subjects. Al-Biruni, another great Muslim scholar of the 11<sup>th</sup> century from Uzbekistan was famous for his world travels. He also recorded his travels with a graphic account of their historical and social conditions. He translated many books from the Indian language, Sanskrit, into Arabic, introducing the work of Indian scholars to Muslim scholars. Al-Idrisi, a 12<sup>th</sup> century Muslim geographer from Southern Spain, studied in Cordoba and traveled widely in Spain, North Africa, Anatolia, and Europe. He settled in Sicily (Italy) and wrote one of the greatest books of descriptive geography- “Kitab Nuzhat al-Mushtaq Fi Ikhtraq-al-Afaq” (The pleasure of excursion of one who is eager to traverse the region of the world.) Al-Idrisi described the customs, people, and the distance between the major cities, the products and climates of the entire known world. He prepared a silver plainsphere on which a map of the world was depicted. He also wrote extensively on medicinal plants. <sup>Encycl. Brit. (1983)-IV</sup>

**Political science-** Although less is known in the West, Muslim scholars have made contributions in the development of political science and defined the role of politics in Islam, where there is no separation of State and Church. Al-Mawardi was a political scientist of the 11<sup>th</sup> century. He was a great jurist, sociologist and expert on political science. He discussed the principles of political science with special references to the functions of Caliphs, the Chief Minister, other ministers and the relationship between various elements of the public and a

government. He laid down clear principles for the election of Caliphs and criticized the established practice by asserting that Shariah (Islamic law) by itself is an insufficient yardstick for justice. His greatest contribution was the introduction of political justice into Shariah. <sup>Ahsani</sup>

**Sociology**- Ibn-Khaldun, a 14<sup>th</sup> century Muslim sociologist who wrote Muqaddimah (Introduction), the first volume of the world history that gave him a special place among historians, sociologists, and philosophers. He documented the psychological, economic, environmental and social factors that contribute to the advancement of human civilization. He postulated the theory of cyclical change in human civilization caused by dynamically changing social, economic, political, and geographical factors. His writings on the development of history on its totality gave a new discipline of social science. As a historiographer, a philosopher of science of history, he has had no equal so far in any age or country. <sup>Encycl. Brit. (1983)-IV</sup>

**Philosophy**- The Muslim philosophers admired the work of Greek philosophers, Plato and Aristotle, wrote commentaries on their works, and made original contributions. Al-Kindi, (9<sup>th</sup> century) was one of early Muslim philosophers who was distinguished as the “Philosopher of Arabs.” He explained that philosophy does not conflict with religion, and philosophy may give us a deeper understanding of the religion (Islam). Al-Farabi, an Andalusian Muslim philosopher of the 10<sup>th</sup> century built his arguments on abstract knowledge and founded a neoplatonic school in Islamic philosophy. He wrote a book on a model city similar to Plato’s Republic that was conceived within the Islamic framework. He made the study of logic more easy by dividing it into two categories: Takhayyul (idea) and Thuboot (proof). The 11<sup>th</sup> century Muslim philosopher and theologian, Al-Ghazali, was the dean of the Nizamiyah University in Baghdad, who portrayed the inability of reason to comprehend the Absolute the Infinite. He further elaborated that an infinite time is related to infinite space. He was able to create the balance between

religion and reason, identified their respective spheres as being the infinite, and the finite respectively. The twelfth century Spanish Muslim philosopher, Ibn Rushd, was regarded as the greatest rationalist of his age. He was a great exponent of harmony of philosophy and religion. He stated that, “Man is neither in full control of his destiny, nor is it fully predetermined for him.” He also promoted the idea that philosophy does not conflict with Islam, and supported rationalism by quoting verses of the Quran. Ibn Rushd’s philosophy influenced the 13<sup>th</sup> century Christian philosopher, St. Thomas Aquinas. He was credited with building the greatest Catholic system of thought that has ever been offered. He synthesized the philosophy of Aristotle, theory of St. Augustine, and philosophy of Al Ghazali, and Ibn Rushd. In his famous work, “Summa Theologica” he followed Al Ghazali’s ‘Yahya ulum al-Din’ (Revivification of Sciences of Religion)<sup>7</sup> He developed an understanding of relationship between philosophy and faith. His understanding of the harmony between religion and natural sciences derives from the high culture of Islamic Spain and Ibn Rushd’s philosophical writings. Another 13<sup>th</sup> century Spanish Muslim philosopher, Ibn al-Arabi, incorporated many fragmented and mono-systematic mystic doctrines into a system, and gave an explicit theoretical formulation. His work: “Fusus Al-Hakim” was regarded as a masterpiece of mystic thought in Sufism. Another renowned Muslim philosopher of the 13<sup>th</sup> century, “Rumi,” is well known to the West. His famous book: “Mathnavi” offers solutions to many complicated problems in metaphysics, religion, ethics, and mysticism. He explains various hidden aspects of Sufism and their relationship with worldly life.

Sayeed (2000)

**Technology**- The Muslim contributions to technology were equally superb. The landmark contribution was the introduction of paper, the knowledge of which had been acquired from China. Muslims established paper factories in Samarkand (Uzbekistan) and later in

Baghdad (Iraq) and Syria. <sup>Salam</sup> During the 8<sup>th</sup> and 9<sup>th</sup> centuries, these mills were spread all over Islamic countries from Spain to Iran, whereas the first paper factory in Europe was established in the late thirteenth century. Paper replaced parchment and papyrus that had a profound effect on the spread and democratization of education, and it became possible to write books and to preserve and distribute knowledge more easily. In some Middle-eastern schools in the 9<sup>th</sup> century, paper was available free of charge. Syria also established glass-making factories producing glassware and pottery of high quality. This technique of glass manufacturing was transferred to Venice, Italy in the 12<sup>th</sup> century. Venice still produces the finest glasswork in the world.

Muslims made advances in the fabric, silk, cotton, and leather industries. During the 9<sup>th</sup> to the 10<sup>th</sup> centuries, hundreds of ships from Muslim countries docked at the shipyard of Canton in China. Muslim traders established a system of letters of credit similar to checks. They worked on all the metals e.g.: gold, silver, bronze, iron and steel. Muslims practiced farming in the scientific way and knew the value of fertilizers. <sup>Rowen (1960)</sup> In the 12<sup>th</sup> century, the Muslim operations in agriculture, irrigation, and manufacturing of farm equipment were far more advanced than European ways. This advanced technology was later transferred from Spain to Italy and Northern Europe. <sup>Al-Hassan (1988)</sup>

Philip Hitti writes, “During all the first part of the Middle Ages, no other people made as important contributions to human progress, as did the Arabs. From 9<sup>th</sup> to 12<sup>th</sup> century, there were more philosophical, medical, historical, astronomical, and geographic works written in Arabic than in any other language of the world. <sup>Hitti (1964)</sup>

**Conclusion-** This chapter has highlighted Muslim scientists’ contributions to civilization.

Unfortunately, this contribution of Muslim scholars and scientists has gradually declined, and

stopped due to the sharp decline in political power, and a significant change in inspiration for education and technological achievement.

When Southern Spain was conquered by Ferdinand in 1490, hundreds of thousands of Arabic volumes of scientific discourses were burned. The Spanish government even prohibited possessing any book written in Arabic by Muslim scholars except the ones that were translated into Latin. Mongols burned the valuable books written by Muslim scholars in Baghdad (13<sup>th</sup> century) and the Crusaders had destroyed many of Muslim scientific works in Syria (12-13<sup>th</sup> century).

Many Non-Muslims translated the original work of Muslim scholars, and Latinized the Muslim names. In subsequent years, Europeans failed to recognize that Muslim scholars did the original work on which current scientific progress was made. Anti-Muslim prejudice also placed a significant role for loss of recognition for Muslim scientists' scholarly work.

Although Muslims' production of scientific work came to a halt due to the factors mentioned above, the scientific progress continued. The major scientific work of Muslims was translated from Arabic to Latin, and Christians in Europe learned medicine, chemistry, physics, math, and philosophy from the books written by Muslim scholars. Many European students graduated from famous universities of Cordoba, Toledo, Baghdad, and Damascus, and returned to Europe to establish and teach in the newer universities. In many European schools, the Arabic language as well as Latin became the medium of instruction. New medical schools were established in Europe, teaching the same curriculum as in Muslim Spain and Baghdad. The textbooks written by Muslim scholars were translated into Latin, and remained a major source of learning until the 16<sup>th</sup> century.

The major reason for Muslim scientific decline is directly related to their gradual loss of interest in scientific subjects. Two parallel systems of education were developed, namely *Shariah*-Science of Islamic jurisprudence and *Ulumul Aqliyyah*- the natural sciences and technology. Most scientific theories such as the theory of evolution was recognized as anti-religious and many Muslims turned away from modern sciences. The decline in progress continued due to apathy towards scientific discoveries. The schools (*Madrasas*) were refraining from teaching the more advanced courses of mathematics, science and philosophy and focused on theology, spiritual and ritualistic aspects of Islam and Islamic Law (*Shariah*). There was an overall demoralization in the new Muslim generation to acquire new knowledge and to do scientific research. Commenting on religious fanaticism, narrow-mindedness and a lack of tolerance, Manzoor Alam stated: “The transfer of science and technology from the Islamic realm to Europe was followed by a sharp decline of political power of Islam, and the rise of fanaticism in Islam dealt a mortal blow to the development of science. It is symbolized by the destruction of the Istanbul Astronomical Observatory in 1580 by the fanatics which was established by Taqiuddin in 1545. The rise of the clerics and fanaticism stifled the growth of science in the countries ruled by Muslim rulers such as the Mooghul (Moghul) Empire in India, Ottoman Empire in Turkey and Arabia and smaller kingdoms in the Maghreb. The language barrier re-emerged forcefully since most of the post 16<sup>th</sup> century scientific researches were conducted in Spanish, German, Italian, French, and English languages. Hence the language of science and technology once again became inaccessible to Muslims all over the world and consequently the Muslim countries rapidly lapsed into decay.” Alam (2002) One wonders about the possible shape of the world today if Muslim scientists had been able to continue their research and scholarly work.

Today, Muslims are seriously under-represented in science. Less than 1% of world scientists are Muslims, whereas 25% of the world's population is Muslim. Muslims have developed a false perception that all knowledge is in the Holy Qur'aan. Most conservative Muslims discourage learning science, regarding it as "Western." Many conservative clerics discourage rational questioning and innovation. But to become a scientist, it is essential to have critical thinking and an inquisitive mind. A scientist's work is dependent on thinking, developing a hypothesis, experimenting, and writing down the observations. Thus, science and technology (*Ilm ul Hikmah*) have been transferred from the East to the West. Science does not belong to a particular ethnic or religious group. It is an on-going evolutionary process that will continue to develop by contributions from different races and groups at different times.

After 400 years of stagnation, the Muslim nation is now once again reawakening and seeking their lost identity. We are reviewing and learning about the contributions of Muslim scholars to science and civilization. We are taking pride in the scientific work of Muslim scientists. We are now recognizing our responsibilities to correct the erroneous notion that modern civilization and scientific advancement are a creation exclusively of any one culture or civilization.

The new generation of Muslim youth will hopefully enhance their self-perception of belonging to a Muslim Nation that has made a significant impact on world civilization. The progress in science we are seeing today is like a building block where all nations – including Muslims and others, have made their contributions. It is the result of cooperation, communication and passing on the wealth of information to successive generations from the Greeks to the Muslims to the West, and finally back to the new generation from East and West. This brief article on the contributions of Muslim scientists may not fully reflect the work they

have done but it will serve as an introduction to their scholarly pursuits and accomplishments. However, just glorification of the past is not enough and we must continuously encourage Muslim youth to become dynamic researchers and follow the path of great Muslim scholars to benefit the fellow human beings everywhere.



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