

Contributions of Muslim Physicians and Other Scholars: 700-1600 AC

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INTRODUCTION

PRIOR TO THE ADVENT of Islam, Arabic society was uncivilized, ignorant, barbarous, and showed little interest in intellectual matters. The Qur'an was revealed to the Prophet Muhammad during the years 612–632 as a book of guidance, and this had a profound effect on Arab society. The first revelation of the Qur'an inspired the Prophet of Islam to acquire knowledge and emphasized the importance of learning in human life. The Qur'an repeatedly urges humankind to understand the forces of nature for the benefit of human beings and their intellectual growth, and it has brought to humanity an interest in scientific thinking.

Proclaim! And your Lord is Most Bountiful. He Who taught [the use of] the pen. Taught man that which he knew not. (96:3–5)

The Qur'an makes it clear that all that is in the heavens and in the earth has been made subservient to human beings, the vicegerents of Allah. Allah has endowed human beings with the capacity to use their intellect to reflect upon things, and to express their ideas in speech and writing (55:1–4).¹ Muslims are encouraged by the commandments of the Qur'an and the Prophetic Sayings to seek knowledge, and study nature to see the signs of the Creator, which thus inspires human intellectual growth. This was the main reason why Muslims made contributions to scientific development. In another verse the Qur'an urges 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)

Qur'anic verses encourage man to reflect (think) and understand the nature God created.

In the earth there are tracks side by side, gardens of grapes, corn fields, and palm trees; growing out of single roots or otherwise. 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)

There are hundreds of similar verses in the Qur'an which describe the mysteries of the universe and stimulate human thinking toward understanding and exploring the laws of nature. The Qur'an emphasizes the need for the observation of natural processes and the reflection upon on what has been observed. No verse in the Qur'an contradicts scientific data. Thus, theology, philosophy, and science are finally harmonized by Islam's ability to reconcile religion and science.² According to the Sayings of Prophet Muhammad, "there is no illness without a cure" and since Allah has created a cure for all diseases except old age, it is necessary for scientists to search for the cure of diseases by advances in medical treatment. The following Prophetic traditions highlight the importance of seeking knowledge:

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.³

Prophet Muhammad further pointed out that only the learned would inherit his legacy, and would be the trustees of Allah on earth. He is said to have encouraged Muslims to travel to China if necessary in search of knowledge. Muslims should not regard the worldly sciences as discouraged or forbidden. The Prophet says: "Whoever goes in search of know-

ledge 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.”⁴ Obviously, when the Prophet emphasized traveling in search of knowledge, he was not referring only to the knowledge of the Qur’an and Shari‘ah, which was readily available in Makkah and Madinah. Therefore, during the early period of Islam, Muslims had a better and deeper understanding of the Qur’an and Prophetic guidance and took it upon themselves to go all over the world to seek knowledge and to 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.⁵

The pre-Islamic Arabs had little knowledge of the physical and experimental sciences. It was only 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. There they discovered the scientific and philosophical works of the Greeks, which aroused their curiosity and the desire to acquire knowledge.⁶ The period between the eighth and fourteenth centuries is regarded as the Golden Age in Muslim history, during which the Muslims established the most powerful empire and produced the most brilliant scientists and scholars of that time. Muslim scholars such as Ibn Sīnā, al-Khawārizmī, al-Rāzī, al-Zahrāwī, al-Bayūnī, Ibn al-Haytham, al-Idrīsī, al-Kindī, Ibn Khaldūn and hundreds of other Muslim scientists made their observations and original research and added a vast treasure of scientific knowledge to mathematics, medical sciences, astronomy, geography, economics, and philosophy. The contributions of Muslim scientists and scholars show the highest quality of scientific development during that period. Muslim scientists were distributed throughout the Muslim empire from Bukhara (Uzbekistan) in the east to Baghdad (Iraq), Isfahan (Iran) and Córdoba (Andalusia – Spain) in the West. They established universities and learning centers that attracted students from all over the world. Córdoba alone contained 17 universities, 70 public libraries and hundreds of thousands of books for students.⁷

Muslim scholars, under the guidance of the Qur’an and Sunnah, which 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 Church dogma suppressed scientific progress. The Church opposed freedom of thought, and even a great scientist such as Galileo was punished for his theory that the earth rotates around the sun, which clashed with the Church's dogma. For a thousand years, scientific, medical, and scholarly work virtually stopped in Europe. Most of the work done by Greeks and some Roman scholars remained dormant. The burning of the great library of Alexandria in 390 AC by fundamentalist Christians had already resulted in the loss of valuable works.⁸

Unfortunately, the West has continually 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, which is usually followed by the 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."⁹

Nevertheless, a number of distinguished historians and scientific investigators (like John Williams, E.A. Myers, Max Meyerhof, Philip K. Hitti, George Sarton, M. Ullman, E.G. 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.¹⁰ Bernard Lewis further clarifies in his book on the Middle East that Islamic scientific development was not solely dependent on ancient Greek knowledge:

[T]he achievement of medieval Islamic science is not limited 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, astron-

omy, and agronomy, the classical heritage was clarified and supplemented by the experiments and observations of the medieval Middle East.¹¹

The output, originality, and creativity in science and technology in the Muslim world continued until about the sixteenth century. During this period, Muslim scientific and scholarly works gradually spread to Europe.¹² Sicily and Spain were the principal centers of such dissemination. From Spain the knowledge penetrated beyond the Pyrenees into western and south-western France and Sicily. The Christian ruler, Roger II, was instrumental in spreading Muslim scientific contributions and culture throughout Italy and across the Alps to various European cities, which themselves became centers of Arab learning.

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

Within two centuries of the death of Prophet Muhammad, the Muslims had conquered new lands, and their empire extended from India in the East to Spain in the West, including Arabia, Syria, Egypt, Iraq, North Africa, Iran, and Turkey. These isolated nations now became part of the Muslim empire. As a result, 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, Arabic 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 and Córdoba became the world’s greatest learning and teaching centers. All the available scientific works on mathematics, philosophy, medicine, and astronomy were translated from the languages of Greece, Rome, India, Persia, and Syria into Arabic. The Abbasid Caliphs, who were recognized for their pursuit of knowledge and support of academics, established the *Bayt al-Hikmah* (House of Wisdom) and sent emissaries to various parts of the world, including the Byzantine Empire, to collect scientific manuscripts. Caliph al-Ma‘mūn established a school of translation and appointed Ḥunayn ibn

Ishāq, a Christian, as the Director, who was a gifted translator and scientist. Ḥunayn ibn Ishāq did major translations of the entire works of Aristotle, Hypocrites, and Galen into Arabic. The *Bayt al-Ḥikmah* had a long-lasting influence on mathematics, economics, astronomy and philosophy, chemistry, and the medical sciences. It produced famous Muslim thinkers such as al-Kindī and al-Fārābī. Caliph al-Muhtadī (ninth century) patronized another scholar, Thābit 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. Sinān, son of Thābit ibn Qurrah became the Director of several hospitals (*bimaristans*) in Baghdad.

The Spanish Umayyad Caliphs' liberal support for academic work also played an important 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 at the entrance of universities in Spain during the Muslim era.¹³ In Spain, the participation of non-Muslim scholars in the scientific enterprises also shows the admirable quality of interfaith tolerance and cooperation adopted by the Umayyad Caliphs.

Commenting on the rise of Islamic civilization and its policy of tolerance towards people of all faiths, John Esposito points 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-Ma'mūn's reign. The House of Wisdom's translation center was headed by the renowned scholar, Ḥunayn ibn Ishāq, a Nestorian Christian. This period of translation was followed by the original contributions of Muslim intellectuals and their 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.¹⁴

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 works for

thousands of years and prevented their extinction. Many translations, along with Arabic commentaries were translated again into Latin and re-introduced into Europe. These translations and the original contributions of Muslim scientists and scholars became the foundation of modern medical and other sciences.¹⁵ Muslim physicians established medical schools in Baghdad and Córdoba 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 Córdoba. The medical encyclopedic work, '*al-Qānūn*' of Ibn Sīna (The Canon of Avicenna), and the books on surgery by Abū al-Qāsim al-Zahrāwī remained the textbooks of medical sciences through-out Europe until the sixteenth century, when European works came to replace these texts.¹⁶

Greek scientists were excellent at 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 in history, introduced the concept of the recording of data based on both observation and experimentation. The Greeks had a strong belief that Aristotle and Plato's opinions were final and that 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.¹⁷ 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.¹⁸

I turn now to elaborate on some more specific contributions to 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 eighth and eleventh centuries, during the Umayyad and

Abbasid eras. Muslims became acquainted with Greek anatomical descriptions, and from 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 Muḥammad found that there were ossicles in the ear, which facilitate hearing.¹⁹ Yuhanna ibn Massawaih dissected a monkey to acquire more information about the human body. Al-Zahrāwī emphasized that the knowledge of anatomy was necessary to become a surgeon.

From the ninth to the twelfth century, 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 attached to these hospitals. One of the early hospitals, Muqtadī, was founded in Baghdad in 916 under the direction of a famous physician, al-Rāzī. 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 by 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 to the hospitals, which 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 Muqtadī Hospital as follows:

In this hospital, the 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 the 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.²⁰

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 tenth century in Baghdad, and later in Damascus. 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. In contrast, the mentally ill patients in hospitals of Baghdad received medication and support services. It was not until 1793 that Philippe Pinel introduced humane treatment for the mentally ill in France, which was adopted elsewhere in Europe at a later date.

Muslim physicians initiated the regulation of medical practice 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 in Italy, followed by Spain and France.

From the European medical schools at Montpellier and Salerno, this vast medical knowledge was disseminated throughout Europe. The *Pharmacopoeia* of the London College of Physicians (1618), a classic work systematizing drugs, recognized this debt to Muslim (and Greek) physicians and contains illustrations of the portraits of a few of these great scholars: Hypocrites; Galen; Avicenna (Ibn Sīna); and Mesuë (Ibn Zakariyyah bin Masawayh).²¹

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 (twelfth century) described how to perform a tracheotomy, and al-Zahrāwī (tenth century) invented many surgical instruments, such as those for the internal examination of the inner ear, the inspection of urethra, and an instrument for the removal of foreign bodies from the throat. His books on surgery contained illustrations of all the surgical instruments that 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 studies. These textbooks were based on original Greek and other existing works and also new scientific data gathered by the Muslim physicians themselves. The most famous medical scholarly works were produced by al-Rāzī (Rhazes, 932),

al-Zahrāwī (Albucasis, 1013) and Ibn Sīna (Avicenna, 1092). Al-Rāzī was the first physician to describe how to differentiate between measles and smallpox. He also discussed the treatment of various ailments by dietary restriction and regulation. After several centuries, we are once again including dietary regulation as the most important part of treatment for a number of severe illnesses like diabetes, hypertension, and heart disease. Al-Rāzī's textbooks were translated into Latin and used in European medical schools until the sixteenth century. Ibn Sīna's encyclopedic work, *Qānūn Fī al-Ṭib*, 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 phthisis and tuberculosis, and the spread of diseases through water and soil. His books contained an authentic record of 760 drugs that were in use, and his writings were translated and used as textbooks for medicine for several centuries in Europe.

Al-Rāzī along with Ibn Sīna 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 al-Haytham's (956–1038) most important contribution was a correct explanation of visual perception. He was the first to prove that rays passed from objects toward the eyes, not vice versa, which was the prevalent belief postulated by Euclid and Ptolemy. He also described how the impressions of objects made upon the eye are conveyed along the optic nerve to the brain, culminating in the formation of visual images.²²

Abū al-Qāsim al-Zahrāwī was born in Córdoba in 936 and he 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 including: *al-Taṣrīf* 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, constituted the first illustrated independent work on surgery. His books remained the leading authority on surgery for 500 years in Europe.²³

Muslim physicians described the anatomy of the lung and bronchi and the interactions between the human body's bloodvessels and air in the

lungs. Ibn al-Nafīs (1213–1288) was the first to describe 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-kīmiyah*. It needs to be pointed out that Muslim scientists who pioneer work in chemistry are often called al-chemists, and sometimes *al-kīmiyah* is associated with a pseudo-science concerned with the transmutation of base metal into gold. *Al* in Arabic means "the," and *kīmiyah* means chemistry; therefore, the word *al-kīmiyah* means "the chemistry" and should not be confused with pseudo sciences.²⁴ The most notable Muslim scientists opposed the false notion that ordinary metals could be changed into gold by a chemical process. The eighth-century Muslim scientist from Iraq, Jābir ibn Ḥayyān (Geber), is known as the Father of Chemistry. He was the first scientist to introduce experimental investigation (*tajribah*) into chemistry by perfecting techniques of crystalization, distillation, sublimation, and evaporation, developing several instruments to perform these tests. He also discovered several minerals and acids, which he prepared for the first time. Jābir described three distinct types of substances: spirit, those which vaporize with heat as camphor and ammonium chloride; metals such as gold, silver, and iron; and compounds which can be converted into powder. He wrote over 2,000 papers on his experimental work. Jābir ibn Ḥayyān advised his students not to accept anything as true until they had 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."²⁵

David Tschnaz stated that Jābir's works on al-chemy (chemistry) were translated into Latin and made their way into Europe. 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, for example, alkali syrup, julep, and alchemy (*kīmiyah*) itself were introduced into European languages – a testimony to the wide-ranging contribution of these early Arab scientists.²⁶

Al-Rāzī, one of the greatest Muslim physicians of the ninth 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 also introduced mercurial compounds for the treatment of various ailments. Ibn Sīna, another brilliant scientist, also adopted Ibn Jābir's methods for chemical experimentation, and used them as the basis for determining the efficacy of new pharmaceuticals.

Gustave Le Bon, the French Orientalist, attributes modern European chemistry to Muslim scientists:

It must be remembered that no sign, 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.²⁷

PHARMACOLOGY

Muslim physicians also made the most significant contributions 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 owing to their expertise in chemistry. Al-Zahāwī (936–1035), a prominent surgeon who was very skilled in the use of simple and compound remedies, was known as a pharmacist surgeon. The thirteenth-century Muslim Spanish scientist, al-Bayṭār, visited Africa, India, and Europe and collected samples of plants through extensive field studies. He classified plants in alphabetical order according to their characteristics and therapeutic qualities. He also recorded the Arabic, Latin, and Berber names of the plants and included information about the preparation of drugs and their administration. He discovered and documented 200 new plants that had not been known previously. His famous book, *Kitāb al-Jāmi' Fī al-Adwiyah al-Mufradah*, (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.²⁸

According to Levey, the Muslims were expert organizers of knowledge, and their pharmacological texts were carefully organized in a way that was useful to the apothecary and medical practitioner.²⁹

MATHEMATICS

Muslims made numerous discoveries in the field of mathematics, which have been passed on to modern science, contributing to the technological revolution of early modern Europe. One of the most notable of these innovations was the concept of zero. Al-Khawārizmī, a Persian scholar living in the ninth century, was appointed as a scientist in the *Bayt al-Ḥikmah* of Baghdad by the Caliph. He developed the concept of algorithms – a method of calculation – which bears the anglicized version of its inventor’s name. His work in algebra was outstanding, for he gave analytical solutions to 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-Muqābalah* (The Compendium of Calculation by Completion and Balancing). The book contained the most important aspects of al-Khawārizmī’s work, and is generally considered the first to have been written on the subject. Al-Khawārizmī also learned the concept of zero from India, and it was transmitted in his works to Europe. The Indians had left a blank for a zero, and al-Khawārizmī’s addition was to give it a symbol, the “o.” Even the English word “zero” is derived from the Arabic name for this symbol *ṣifr*. Leonardo Da Vinci studied the Arabic numeral system and introduced it to Europe.³⁰

Abū al-Wafā al-Buzjānī (940–997) developed trigonometry. He was the first person to show the generality of the sine theorem relative to spherical triangles.³¹ Al-Ṭūsī, another Muslim scientist of the thirteenth century, developed spherical trigonometry, including 6 fundamental formulas for the solution of spherical, right-angled triangles.

ASTRONOMY

A Muslim astronomer of the tenth century, al-Battani made several original contributions to the study 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 visibility of the new moon. European astronomers used his observations of solar eclipses in 1749 to determine the acceleration of the motion of the moon.

Muslims invented the compass and al-Farganī (860) estimated the circumference of the earth to be 24,000 miles. Muslims were the first to use the pendulum, build observatories, catalog 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 pseudoscience. The thirteenth-century Muslim astronomer, al-Ṭūsī, earned his fame by producing astronomical tables called *al-Zij Ilkhanī*, 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 tenth century, Muslims built an observatory in Baghdad and the famous Samarqand observatory was built in the thirteenth century when al-Ṭūsī worked on the measurements of planetary movements. Ibn Shaitar of Damascus (fourteenth century) continued the work on planetary movements, using a combination of perfect circulatory motions. The famous European astronomer, Copernicus, was familiar with Ibn Shaiṭar's work and used his theories to suggest a heliocentric system of movements of planets, as opposed to Ptolemy's geocentric system.³³

GEOGRAPHY

Al-Mas'ūdī, a tenth-century Muslim geographer and historian, traveled to Baghdad, India, China, and several other countries of the world. He described his experiences as well as the people, climates, and the geography and history of the various countries that he visited. He documented historical events chronologically and wrote 34 books covering a variety of these subjects. Al-Bayrūnī, another great Muslim scholar of the eleventh century from Uzbekistan, was famous for his world travels, which he also recorded in a graphic account of the history and societies of the people that he encountered. He translated many books from the Indian language, Sanskrit, into Arabic, thus introducing the work of Indian scholars to Muslim scholars. Al-Idrīsī, a twelfth-century Muslim geographer from Southern Spain, studied in Córdoba and traveled widely in Spain, North Africa, Anatolia, and Europe. He settled in Sicily and wrote one of the greatest books of descriptive geography: *Kitāb Nuzuhāt al-Mushtāq Fī Ikhtrāq al-Āfāq* (The Pleasures of Travel by One who is Eager to Traverse the Regions of the World). Al-Idrīsī described the

people and the customs, as well as the distance between the major cities, and 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.³⁴

POLITICAL SCIENCE

Although less is known about this aspect in the West, Muslim scholars have contributed to the development of political science and defined the role of politics in Islam, where there is no separation of State and Church. Al-Māwardī was a political scientist of the eleventh century and was a great jurist, sociologist, and expert on the subject. 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 Shari‘ah (Islamic Law) by itself was an insufficient yardstick for justice. His greatest contribution was the introduction of political justice into Shari‘ah.³⁵

SOCIOLOGY

Ibn Khaldūn, a fourteenth-century Muslim sociologist wrote *Muqaddimah* [Introduction], the first volume of world history, which gave him a special place among historians, sociologists, and philosophers. He documented the psychological, economic, environmental, and social factors that contributed 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 in its totality gave rise to a new discipline, that of social science. As a historiographer, and a philosopher of the science of history, he has had no equal so far in any age or country.³⁶

PHILOSOPHY

The Muslim philosophers admired the work of Greek philosophers, Plato and Aristotle, wrote commentaries on their works, and made original contributions. Al-Kindī, (ninth century) was one of the early Muslim philosophers who was distinguished as the “Philosopher of the Arabs.” He explained that philosophy did not conflict with religion, and could

give one a deeper understanding of the religion (Islam). Al-Fārābī, an Andalusian Muslim philosopher of the tenth 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 that of Plato's Republic though conceived within the Islamic framework. He also made the study of logic easier by dividing it into two categories: *Takhayyul* (idea) and *Thubūt* (proof). The eleventh-century Muslim philosopher and theologian, al-Ghazālī, was the dean of the Nizāmiyyah University in Baghdad; he portrayed the inability of reason to comprehend the Absolute, the Infinite and further elaborated that an infinite time is related to infinite space. He was able to create a balance between religion and reason, identifying 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 the harmony of philosophy and religion, stating: "Man is neither in full control of his destiny, nor is it fully predetermined for him." He also promoted the idea that philosophy did not conflict with Islam, and supported rationalism by quoting verses of the Qur'an. Ibn Rushd's philosophy influenced the thirteenth-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, the theory of St. Augustine, and the philosophy of al-Ghazālī and Ibn Rushd. In his famous work, *Summa Theologica*, he followed al-Ghazālī's 'Ihyā' 'Ulūm al-Dīn' (Revival of the Sciences of Religion) and developed an understanding of the relationship between philosophy and faith. His understanding of the harmony between religion and natural sciences derived from the high culture of Islamic Spain and Ibn Rushd's philosophical writings. Another thirteenth-century Spanish Muslim philosopher, Ibn al-ʿArabī, incorporated many fragmented and mono-systematic mystic doctrines into a system, and gave an explicit theoretical formulation. His work, *Fuṣūṣ al-Ḥikam*, was regarded as a masterpiece of mystic thought in Sufism. Another renowned Muslim philosopher of the thirteenth century, Rūmī, is well known to the West. His famous book, *Mathnawī*, 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.³⁷

TECHNOLOGY

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 and later in Baghdad and Syria.³⁸ During the eighth and ninth centuries, these mills were built all over the Muslim world from Spain to Iran. In contrast, the first paper factory in Europe was established as late as the late thirteenth century. The replacement of parchment and papyrus with paper had a profound effect on the spread and democratization of education, for it became possible to write books and to preserve and distribute knowledge more easily. In some Middle Eastern schools in the ninth century, it 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 in the twelfth century. Venice still produces the finest glasswork in the world.

Muslims made advances in the fabric, silk, cotton, and leather industries. During the ninth and tenth centuries, hundreds of ships from Muslim countries docked at the port of Canton in China. Muslim traders established a system of letters of credit similar to checks. They worked with all kinds of metal, for example, gold, silver, bronze, iron, and steel. Muslims practiced farming in the scientific way and knew the value of fertilizers.³⁹ In the twelfth century, Muslim agriculture, irrigation, and manufacture of farm equipment were far more advanced than those of non-Muslim Europe. This advanced technology was later transferred from Spain to Italy and Northern Europe.⁴⁰ 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 9th to 12th century, there were more philosophical, medical, historical, astronomical, and geographic works written in Arabic than in any other language of the world.⁴¹

CONCLUSION

This chapter has highlighted Muslim scientists' contributions to civilization. Unfortunately, these contributions gradually declined, and came to a halt owing to a rapid loss of political power, and a marked lack of 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 went to extraordinary lengths to prohibit the possession of any book written in Arabic by Muslim scholars except those which had been translated into Latin. In the thirteenth century, Mongol armies burned valuable books written by Muslim scholars in Baghdad, and in the twelfth and thirteenth centuries, the Crusaders destroyed many Muslim scientific works in Syria.

Many non-Muslims translated the original works of Muslim scholars and Latinized the Muslim names. In subsequent years, Europeans failed to recognize that Muslim scholars had done the original work on which current scientific progress had been made. Anti-Muslim prejudice has also played an important role in the loss of recognition of Muslim scientists and their scholarly work.

Although the production of scientific work and knowledge by Muslim scholars was brought to a halt owing to the factors mentioned above, the scientific progress that they had generated continued. Major scientific works of Muslims were translated from Arabic to Latin, and Christians in Europe learned medicine, chemistry, physics, mathematics, and philosophy from the books written by Muslim scholars. Many European students graduated from the famous Muslim universities of Córdoba, 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 that of Muslim Spain and Baghdad. The textbooks written by Muslim scholars were translated into Latin, and remained a major source of learning until the sixteenth century.

The major reason for the decline in scientific achievement in the Muslim world was the Muslims' gradual loss of interest in scientific subjects. Two parallel systems of education were developed, namely Shari'ah – the science of Islamic jurisprudence, and *al-'Ulūm al-'Aqliyyah* – the natural sciences and technology. Most scientific theories such as the theory of evolution were recognized as anti-religious and many Muslims turned away from modern sciences. The decline in progress continued owing to apathy toward scientific discoveries. The schools (*Madāris*) refrained from teaching the more advanced courses of mathematics, science, and

philosophy, focusing instead on the theological, spiritual, and ritualistic aspects of Islam and Islamic Law (*Shari'ah*). 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 states:

The transfer of science and technology from the Islamic realm to Europe was followed by a sharp decline of the 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 Taqiyuddin 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 Maghrib. The language barrier re-emerged forcefully since most of the post 16th 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.⁴²

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 one percent of the world's scientists are Muslim, whereas 25 percent of the world's population are Muslim. Muslims have developed a false perception that all knowledge is in the Qur'an. Most conservative Muslims discourage the study of science, regarding it as "Western." Many conservative imams discourage rational questioning and innovation. Nevertheless, to become a scientist, it is essential to have the ability to think critically and to have an inquisitive mind. A scientist's work is dependent on thinking, developing a hypothesis, experimenting, and recording the observations. Thus, science and technology (*Ilm al-Hikmah*) have been transferred from the East to the West. Science does not belong to a particular ethnic or religious group. It is a never-ending evolution that will continue to occur with contributions from different races and groups at different times.

After 400 years of stagnation, the Muslim community is now re-awakening and seeking its lost identity. We are reviewing and learning about the contributions of Muslim scholars to science and civilization.

We are taking a 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 exclusive to a particular culture or civilization.

The new generation of Muslim youth will hopefully enhance its self-perception of belonging to a Muslim community that has made a significant impact on world civilization. The progress in science that we are seeing today is like a building to which all nations – both Muslim and non-Muslim, 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. Although this brief article on the contributions of Muslim scientists may not fully reflect the work that they have done, it will, nevertheless, serve as an introduction to their scholarly pursuits and accomplishments. However, merely glorifying the past is not enough, for we must continually encourage Muslim youth to become dynamic researchers and follow the path of great Muslim scholars to benefit their fellow human beings everywhere.