Science and Technology in Islamic Spain

By Zakaria Virk, Toronto, Canada

Muslims ruled Spain for nearly eight centuries giving it a culture of enlightenment. Of the many remarkable features of Islamic Spain, one was its exquisite cultivation of sensuous pleasures with an astonishing quest for learning. The capital city of Cordoba was throbbing with music, its streets steeped in oriental perfume and royal palaces filled with incredible luxury. Notwithstanding this luxurious lifestyle, the houses in the city contained superb libraries of ten to fifty thousand books, and eagerness for learning and knowledge was unmatched with any previous civilization.

“Spain was a region of light amid Christian, yet benighted Europe”, observes Washington Irving, “ externally a warrior power fighting for existence; internally a realm devoted to literature, science, and the arts, where philosophy was cultivated with passion, though wrought up in subtleties and refinements; and where the luxuries of sense were transcended by those of thought and imagination”. The Alhambra, first edition 1832, London. 1983 edition page 255, Boston, USA)

Consider the following facts, it was in Islamic Spain that first human flight took place, it was via Muslim Spain that Arabic numerals(*al-Huruf al-Ghubariyya* –dust characters) were introduced into Europe, the paper was also introduced into Europe from Islamic Spain, the greatest library during the Middle Ages existed in Islamic Spain, the first book on comparative religion was written here, the crystal was discovered in Cordoba, the earliest surgical instruments were made in al-Andalus, toothbrush and toothpaste was invented in Islamic Spain.

It was a Spanish Muslim physician who first described the real function of the retina, it was a Spanish scholar who first rejected Ptolemy’s geocentric system, and it was also a Spanish Muslim physician who described the contagious nature of the plague.

Between the eighth and the thirteenth century, Muslims were torchbearer of a brilliant civilization in the world while Europe was going through its period of Dark Ages(5th to 10 century). For three hundred years al-Andalus (meaning land of the Vandals, people who ruled Spain before Arabs) wrote a bright chapter in the intellectual history of the world. Numerous inventions and discoveries were made in Cordoba that was the political and intellectual center of Europe. During the Middle Ages (1000-1453) Cordoba was not the only jewel of the world, but the mother of all towns of Europe. It was a favorite abode of intellectuals, to it flocked seekers of science, writers, literary giants, and poets, in it were composed books of unsurpassed writings. *Mecca achieved greatness by the birth of Prophet*

Muhammad (SAW), Medina by the success of his mission but Cordoba achieved greatness due to its learning. ***(1)***
"***It surpasses all cities of the world***", a famous Muslim historian al-Maqqari (d1632) observed "***in four principal features: its bridge over the Guadalquivir, its mosque, its palace al-Zahra, and above all the sciences cultivated therein." (2)***

The palace mentioned in this quotation was al-Zahra which was built by 10,000 laborers, 3000 beasts, its cost 300,000 dinars per year, its imperial palace could accommodate 6314 women, 3752 body-guards, and pages, it had 4000 columns of marble & gold. It consisted of many palaces, a mosque, a zoo, a compound for birds, and shops for making tools. Caliph Abdur Rahman III spent 25 years building it. There were 37 libraries in Cordoba, numerous bookstores, 800 public baths, and six hundred mosques. There were 150 hospitals, 600 inns, 80,455 shops, 130,000 houses, 4300 markets, 10,000 mansions with exquisite gardens. These mansions bore such names *The Vale of Paradise, The Garden of Of Wonder, The Beautiful Valley.* It had a population of one million in the 10th century whereas now it is only 100,000.

While Europe was deep in its slumber of ignorance, this city was rearing men of culture, erecting magnificent buildings, writing books, and producing works of art. There were 5000 mills along the river grinding corn for the workers. There were 20 miles of gardens. So many flowers were planted on one of the hills close to the palace that it was called Mountain of Flowers. They had such a passion for cleanliness that a poor worker would rather spend his last coin on soap than on food. This was the first city in Europe to have street light, after sunset a person could walk in a straight line for ten miles under the light of public lamps. Compare this to London seven hundred years later where there was not one street lamp, and in Paris people walked in the mud.

Cordoba dazzled the eyes of its inhabitants as well as people living in the neighboring countries. A German nun Hrosvitha (d ca 1002) described the splendor of Cordoba under Caliph Abdur Rahman II in this way, " ***In the western parts of the globe, there shone forth a fair ornament, a venerable city, haughty because of its unwonted might in war, a city well cultured, rich and famous known by the name of Cordoba, illustrious because of its charms and also renowned for all resources, especially abounding in the seven streams of knowledge."(3)***

Whenever Christian rulers needed a physician, an architect, or a dressmaker, it was Cordoba they invariably turned to Scholars were so many that a judge of Valencia wrote a large volume entitled "*History of the Learned Men of Spain".* Caliph al-Hakam II patronized the learned as he was a scholar in his own right. He founded 27 free schools in Cordoba, endowed chairs in the university inviting professors from the East.

There was no superior to him in the knowledge of history and biography. He himself was the author of the book '*History of Spain*". He read and annotated a large number of his books in the royal library, which consisted of 400,000 books, its catalog consisted of 44 volumes, each volume having twenty sheets of paper, which contained nothing but the titles and descriptions of the books. (*page 169, vol II, Muhammadan Dynasties, by Pascual Gayangos, extracted from Nafhtu tibb by L.D Khatib*) It was a favorite saying in Islamic Spain that "*when a*

musician dies at Cordoba, and his instruments are to be sold, they are sent to Seville, when a rich man dies at Seville, and his library is to be sold, it is sent to Cordoba". ***(4)***

Fabulous library

In the history of Islamic Spain, Caliph al-Hakam II (961-976) is fondly remembered because of his voluminous library. Love of books came to him from his illustrious father, Caliph Abdur Rahman III who in fact started collecting for this library. It is said that there were 400,000 volumes in this *Khizanatul Kutab (library).* All these books were cataloged in 44 volumes. Al-Hakam, an avowed bibliophile, offered extravagant prices for new and rare books, so much so that he would give 1000 gold dinars to anyone who would bring him an original volume of poetry. For instance, he sent 1000 dinars to the Iranian poet al-Isfahani in order to get the first copy of his composition, *Kitab al-Aghani.*

The library was very spacious, the bookcases were of scented wood, and the wall of the building made of alabaster & mosaic, the floors were made of quality marble. The adjoining room was occupied by a large number of copyists, binders, and illuminators. These copyists wrote on paper of fine quality. The staff included people of both sexes. The chief librarian was **Talid,** and one of the secretaries was a woman named Labna, while anther woman **Fatima** was an elegant writer who traveled in distant lands in search of books.

Aisha had her private library, she wrote many books and was so wedded to books that she remained single all her life. An Almohade princess **al-Wallada (d1072)**, daughter of Caliph Muhammad II al-Mustakfi, was famous for her personal charm, wit, and poetry. Her home in Cordoba was a meeting place for scholars and leading poets. She possessed all the traits of an outstanding lady, she was more like a liberated woman of the 20th century. **Safiya** of Seville was a distinguished poet ad orator who also excelled in the art of calligraphy. Some women distinguished themselves in various fields of science and some entered the royal harem on the strength of their intellectual achievements.

Educated women earned their living, and some preferred to have a literary career than getting married. Hafsah of Granada (d 1184) was another poet who was renowned for her beauty, talents, nobility, and wealth. Her poetry, remarks famous Spanish historian al-Makkari, "was like the language of doves." (The Alhambra, Irving, page 258, 1983, USA) When Islam was at the height of its glory, libraries were not only a symbol of learning but also a mark of prestige. It was considered fashionable by the wealthy and poor to have libraries in their homes. " *Rich people however illiterate spared no labor or expense in amassing books.*" **(6)**

While al-Hakam's imperial library had so many books on every known subject, surprisingly the biggest library in Europe in 1300 was in Canterbury comprising 5000 books, the one in Cluny (France) had only 570 books.

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here were also seventy public libraries in Cordoba. Copy shops employed women, books shops were as busy as jewelers. The staff at the Royal library included scholars who translated Greeks works into Arabic. Love of learning was infused in people to such an extent that even slaves, poor workers, and eunuchs were literate; this was at a time when nobles in Rome could not even write their names. The Royal library became a symbol of Islamic civilization that attracted learned men in large numbers from the Muslim world.

Wealthy individuals had their private libraries in their mansions, " *where studious could dive into the fathomless sea of knowledge, and bring up its inestimable pearls*." (Nafhut Tib by ibn al-Khatib, extracts by al-Makkari, translated by Pascual de Gayangos, page 139, Vol I, NY 1964).

One wonders what became of this library. According to Prof. Hitti, Emir Hisham's chamberlain Muhammad Ibn abi Amer decided to burn all books on philosophy and astronomy blacklisted by the Ulema, religious scholars. **(7)** Another author opines that on 18th December 1499 under orders from Queen Isabella's confessor, Cardinal CISNEROS, a huge pile of copies of the Koran and 70,000 Islamic theological, philosophical, and scientific works were jubilantly burned in a public square in Granada. **(8)** (Shades of the Alhambra, page 45, by R. Trevelyan, London 1984).

Books were also transferred to cities like Toledo, Valencia, Barcelona, and Granada after Cordoba fell in 1236. Not all was lost though; it is estimated there are close to 250,000 Arabic manuscripts preserved in many European & Eastern libraries. The biggest collection is in the university libraries of Oxford, Durham, Cambridge, Berlin, Gottingen, Bonn, Heidelberg, Tubingen, Vienna, Vatican, Istanbul, and Escorial library of Madrid. The catalog of Islamic manuscripts in the British Museum consists of two volumes, whereas the catalog of Arabic manuscripts in the Berlin library is in ten volumes.

In North America the biggest collection of 100,000 Islamic books at McGill University Library in Montreal. The manuscript collection consists of 170 volumes in Arabic, Persian, and Turkish. There is a valuable collection of 1000 rare books printed in lithography. www.library.mcgill.ca/islamic

Paper & book production

The Muslims learned the manufacturing of paper from Chinese in Samarkand in 704. The paper-mills in Jativa supplied Muslim scholars with an unlimited supply of paper. The quality of the paper was so good that copyists could write rapidly with great ease. It is said that nearly 70,000 books were published every year in Cordoba. One copy shop employed 170 women; wealthy people employed their own copyists. Many scholars wrote on three or four branches of knowledge and produced books by the hundreds. Averroes, for instance, was not only a master of medicine but other sciences also. It is said that Ibn al-Khatil wrote 1100 books, Ibn Hasen 450 books, while Ibn Hazm wrote close to 400 books. Ibn al-Nafees wrote a book *Kitab al-Shamil* (Comprehensive book on the art of medicine) that consisted of 300 volumes, of which he published only eighty. (Dictionary of Sc. Biography, Vol IX, page 603). The majority of bookshops were housed in booths by the main Cordoban mosque. The booksellers were mainly copyists or calligraphers. Book decoration flourished with elaborate designs, gold lettering was impressed upon book covers by means of metal dies. Caliph Abdur Rahman III spent hours on end discussing books with the scholars. The Greek emperor sent him a copy of the famous work of Dioscorides, written in gold ink on a fine parchment with pictures of medicinal plants. A Greek monk was also sent to translate it from Greek who was assisted by Hasday ben Shaprut. (**A copy of the letter from the Greek emperor in attached here**)

"*Until the renaissance*", observes Bernard Lewis, "*Arabic was the most translated language in the world, both in the number of books translated and in the number of languages into which these translations were made."* **(9)**

Andalusian scholars wrote on a wide variety of subjects as sciences, literature, administration, commerce, industry, drugs, arts, and military affairs. Arabic possessed an enormous amount of vivid vocabulary, consequently it was a preferred choice for writing. Arabic was, in fact, an international language, its knowledge was considered the mark of culture during the Middle Ages. At the time of the conquest of Spain in 711, Latin was the language of the church and literature, population spoke Romance dialect (Castilian, Catalan, and Aragones), and Hebrew was the language of the Jews.

Arabic however became lingua franca thus unifying Muslims and non-Muslims in Spain. From the ninth century onward, it was used for daily communication, administration, and literary expression. Writing in Arabic meant that the work gets the widest possible circulation. For 800 years Arabic occupied a prominent place in the world. At one time Arabic was regarded in Europe as the language in which secrets of nature were found.

Educational system

In the beginning education in Islamic Spain was dependent on the eastern centers of Islam. During the tenth and the eleventh centuries, many Spanish Muslim scholars journeyed in quest of scientific knowledge to Egypt (Abul Salt), Iraq (Kirmani, ibn Firnas), Syria, and some went as far as Persia. While there they learned everything they could in the fields of medicine, astronomy, mathematics, and ophthalmology. Many scholars from eastern lands of Islam migrated to Spain for better job opportunities. In the next two centuries, the twelfth & thirteenth were golden periods of science in Spain.

Education was not a state responsibility in Islamic Spain, many princes and wealthy founded schools. There was a school in every village, normally attached to a mosque. Mosques in every town served as an educational center. Every major mosque had a library containing works of theology, philosophy & science. Mosque was a meeting place for lectures and scientific discussions as well.

Elementary education consisted of memorizing the Quran, while reading and writing began at home. The teacher sat with his back to a column in the mosque, while pupils sat on the floor in a ring. Students had sharp memories. Teachers provided the services for food or fixed salary. The classes were very informal. Koran was the first textbook. In the university, teachers taught for a fee. Students spent five to fifteen years in higher studies. The teacher taught unsystematically, just what he cared and often roamed from philosophy to theology to astronomy, to the history of medicine.

At the mosque, a student would receive education in jurisprudence, grammar, lexicography, exegesis of the Qur'an, and Prophetic tradition. This training was under-seasoned teachers who were renowned authorities in a certain discipline. **(10)**

Several cities had universities such as Cordoba (Ar. Qurtuba), Seville (Ar. Ashbiliya), Toledo, and Granada(Gharnata). The University of Cordoba, founded by Caliph Abdur Rahman III(912-961) was the most celebrated university in the world in the tenth and eleventh century. It provided courses in astronomy, mathematics, medicine, history, literature, Arabic, the Quran, theology, and law. There were ten thousand students enrolled in it. It was housed in the Grand Mosque of Cordoba; here lead pipes supplied water. The

university invited distinguished professors from the Islamic East to head the departments. The degree from this university guaranteed a lucrative job anywhere in the country.

The University of Granada was founded by Emir Yusef abul Hajjaj in 1340; the building had its gates adorned by stone lions. The curriculum included medicine, chemistry, astronomy, philosophy, and theology. One administrator was poet historian *Lisanu din ibn al-Khatib* (1313-1374) who authored about sixty books. An inscription on one of the main buildings read, "**the world is supported by four things only, the learning of the wise, the justice of the great, the prayers of the righteous, and valor of the brave."**

Christian students from Castile and Aragon came here for studies. The government of the university was entrusted to a rector, who was chosen from amongst the professors. A learned Muslim, Christian, or a Jew could be appointed to this post. Annual meetings were held in the universities to which the public was invited.

Poems were recited by leading poets and lectures delivered by eminent teachers. *Professors of theology or law wore a turban, over which was thrown a scarf called the Tailasan. Sometimes it was worn over the shoulders. These scarves gave rise to European academic scarves and hoods. (Page 453, Hist of Saracens, Ameer Ali, 1955). Some* students from Spain traveled to Baghdad or Cairo for graduate work just as Muslim students nowadays travel to universities of Oxford or Harvard. Scholars from Cordoba and Seville traveled to the farthest corners of Islamic dominion, like Kufa, Basra, Baghdad, Cairo to exchange ideas.

During the 18th century, 85% percent of the population in Europe was still illiterate, while the great majority of the population in Islamic Spain could read and write seven hundred years before.

Toledo's Fame

Christian students coming to Islamic Spain were familiar with the beautiful streets of Toledo, Cordoba, and Seville. In contrast to this, there were no sewers, no streetlights, and no paving in London or Paris. Bathing became popular in Europe in the 14th century, and soap that was invented by Arabs got into wide use. There was money in circulation in Spain while in Europe there was none. Minted coins were used in al -Andulas*, the dinar* was the gold unit and *dirham* was the silver unit. Christian rulers of re-conquest used Islamic patterns on their coins for over two hundred years.

The earliest gold coinage struck in Italy was called *Byzantine Saracenati*. (Note Saracen, Muslim) It bore Arabic inscriptions, brief text from the Quran, a reference to the Holy Prophet, and a date calculated in Hijra.

Toledo, once the capital of Spain, played the leading part in the transmission of scientific knowledge from Islamic Spain to Europe. It made its name through translations of Arabic scientific works into Latin. Toledo's translation academy that was modeled after *Baitul Hikmah* of Baghdad (750-900), lasted from 1135-1284. There existed in the city a rich Mosque Library of Arabic scientific works whose fame had penetrated far into European cities. It became a resort for eager scholars. The intellectual atmosphere of the city was just right as there were Arabs of mixed lineage, there were bilingual Spanish scholars, there were foreign scholars, & there were Jews in the city who were learned in scientific lore.

The translation was one of a number of creative things that a scientist did in those days. Translations were mainly made of literary or scientific texts. Translations were of two types: active (translation with analysis of concepts) and a passive (with meaning than mere utterance, Lafzi). Translation teams consisted of two men.

An Arabic speaker would read the original in Arabic and then translated it aloud, word by word into a vernacular (i.e. Castilian), then his partner wrote down the translation of each Castilian word in Latin. For example, Ibn Daud worked with Gundisalvi in translating Ibn Sena's De Anima. Similarly, Michael Scot worked with A. Levita, Plato of Tivoli with Bar Hiyya, and Gerard of Cremona with an Arab Galip. The elite group of translators during the 12th century was made up of Hugh of Santalla, John of Seville, Gundisalvo, Gherardo Cremonese (Italian), Plato of Tivoli, and Herman the Dalmatian (German), Michael Scot, and Adelard of Bath (d.1160 -English). The Quran, was translated here into Latin in 1142 by a team of translators consisting of four Christians and one Muslim.

These scholars were not mere translators, they were in fact pioneers of the European renaissance.

The earliest translations were those of mathematics, astrology, medicine, psychology, logic, and philosophy. The translations made were faithful, every word in Arabic originally found some Latin word corresponding to it. For instance, **dura mater** (*al Umm al- Jafiyya*, coarse mother – the tough membrane enveloping the brain) **pia mater** (*al Umm al-Raqiyya*, thin mother – the thin membrane covering the brain) When difficulty arose with the translation of technical words, in such cases words were transliterated from Arabic. Or sometimes Arabic words were taken over as they stood and Latinized.

An Englishman Robert of Chester translated in 1145 *al-Jabr wa-Muqabala* of al-Khawarizmi. Arabic numerals were introduced in Europe from Toledo after this Latin translation, (*Algoritmi de Numero Indorum)*, thus giving a new word algorithm (Spanish Guarismo) which is a corruption of his surname. Adelard of Bath arrived here in 1126 and translated into Latin astronomical tables of al-Majriti. Michael Scot (d 1235) translated works of Ibn Sena and Ibn Rushd. Gerard of Cremona (d1187) was equivalent to Hunayn ibn Ishak (809-877) who translated 71 Arabic works into Latin.

The net effect of this intellectual activity was that it revolutionized the thinking of European nations and sharpened their wits. On the sterile soil of Europe, it planted the seeds of learning. It also paved the way for funding of universities in several cities in the 12th century, i.e.University of Salerno and Bologna in Italy, Paris, and Montpellier in France, and Oxford in England. It worked as a spark to ignite the flame of knowledge that has not dimmed after six hundred years of burning. By the end of the 13th century, Europe had acquired from Islamic Spain all it could and was well on its way to the path of the renaissance in the 14th century.

Scholars of Fame

Islamic Spain produced eminent scholars in many fields, astronomy(al-Bitruji, al-Zarqali, ibn Aflah, al-Majriti), medicine (Ibn Zuhr, Az-Zahrawi), philosophy (ibn Bajja, Ibn Tofail, Ibn Rushd), lexicography, history, geography(al-Bekri) and botany(Ibn Baitar). Andalusian scholars were interested in these subjects mainly because of religious

significance. Mathematics was needed to figure out inheritance, distances between towns, prices of commodities. Astronomy was required to determine the position of Kaaba from any place in the world, the timing of prescribed prayers, and seasons. Medicine was needed for the preservation of health and purity of the soul. **(11)**

There were several observatories in Islamic Spain, Zarqali worked on his Toledan Tables at Toledo, Jabir ibn Aflah used the minaret of Grand Mosque of Seville (*La Giralda*) as an observatory, and Ibn Bajja had his private observatory. The **Giralda Tower** of Seville was completed in 1198 after 25 years of elaborate design & construction work. It is 300 feet tall with a base of 300 square feet. There are no stairs, only ramps, so one can go to the top on the back of a horse. It had seven rooms, corresponding to seven planets. Subsequently converted into a belfry, it still dominates the city. The writer visited this tower in August 1999, which was flocked with tourists.

A thousand years ago knowledge was not as compartmentalized as it is today, a mathematician could be a philosopher and a musician, while a poet could be a physician and philosopher. Physics, mathematics, astronomy were closely tied, if a scholar wrote on one he wrote on the other as well. A number of scientists did their research in a number of fields as will be evidenced from the following list.

Ahmad ibn Ilyas: (death ?) He was the first physician of Islamic Spain who lived during the reign of emir Muhammad. (852-886).

Abbas ibn Firnas: (d887) He was poet laureate and astrologer of emirs Abdur Rahman II and Muhammad I. He was famous by virtue of his ability to make new inventions. He brought from Baghdad the tables of *Sindhind,* which greatly influenced the development of astronomy in Europe. **He was the first in history who made a scientific attempt at flying**. His flying equipment consisted of a suite of feathers with wings that carried him a distance in the air. When he alighted, he hurt himself because his suit did not have a tail. He introduced oriental music in Spain. He constructed in his home a planetarium, a clock, and an armillary sphere; and is credited with the discovery of rock crystal. (**12)** He introduced the crystal cutting technique in Spain.

Ibn Abd Rabbihi: (860-940) of Cordoba was laureate of emir Abdur Rahman III. His book *Aqd al-Farid* (The Unique Necklace) is considered to be the first literary history of Islamic Spain. His nephew Saeed Abd Rabbihi was a physician-poet.

Rabi ibn Zaid al-Usquf: (d961) He was bishop of Cordoba under emir al-Hakam II. He wrote mainly in Arabic. He produced numerous astronomical treatises and dedicated a calendar called *Kitab al-Anwa* to Caliph al-Hakam II.

Joseph the Wise (Sapien) L984 He wrote a treatise on multiplication and division.

Hasday ibn Shaprut: (d990) He flourished at the court Abdur Rahman III and al-Hakam II. He was the court physician of both these emirs. He translated Greek works into Arabic and was a great patron of science. He discovered a panacea called *al-Farooq* (the best). When Greek emperor Constantinus VII sent the gift of an ancient manuscript of *Materia Medica* by

Dioscorides to Caliph Abdur Rahman III, Hasday was among the translators (one Greek-speaking Arab, and five Spanish) who assisted the Greek monk Nicholas in translating it. He wrote a letter to the King of Khazzars describing Islamic Spain.

Yahya ibn Ishaq: He served as a physician and vizier at the court of Emir Abdur Rahman III (912-961). He authored a medical work in five volumes.
Maslama ibn Ahmad **al-Majriti : (d1007)** He was born in Majrit (Madrid) but flourished in Cordoba, where he established a school in which future scholars like Ibn Khaldun and az-

Zahrawi studied. He was the first astronomer and mathematician of al-Andalus. He edited and corrected planetary tables (ZIJ) of Khawarizmi, wrote a treatise on the astrolabe, a commentary on Ptolemy's *Planisphere*, a book on commercial arithmetic *al-Muamilat*, and a book on the generations of animals. His famous disciples were al-Karmani (d1066), ibn Samh, and ibn Saffar.
He mentioned the erotic power of amicable numbers. In chemistry he wrote two books *Ghiyataul Hakim* (Aim of the Wise) and *Rutabatul Hakim* (Sage's Step), the first book was translated into Latin under the title Picatrix in 1252 by order of King Alfonso the Wise. It remained the mainstay of chemistry literature in Europe for many years.

Adelard of Bath translated his astronomical tables into Latin in 1126. (Adelard of Bath, by C. Burnett, page 88, London, 1987) He was the first person who introduced the study of sciences, especially mathematics and chemistry in Islamic Spain. Among his honorific title was *al-Hasib* (mathematician) for he was considered a leader in this field. His book *Kitab al-Hayah* was translated by Michael Scot in 1217 while John of Seville translated his treatise on the astrolabe.

Maslama created a school of astronomers consisting of his students and their students marking the beginning of science as an organized activity in Islamic Spain. All his students immersed themselves in the works of al-Khawarizmi, all commented on the use of the astrolabe, and zij al-Sindhind. **(13)**

Qazi Saeed al-Andalusi (1029-79), in his book Tabaqat al-Umam, described Maslama as " the leader of mathematics in al-Andalus in his time, and no one before him was more learned in astronomy. He was a capable observer of the stars and was filled with a desire to understand the book of Ptolemy known as Almagest. He produced distinguished students, such as no other expert in al-Andalus produced. " L. Cheiko, Beirut, 1912, french translation by Blachere, Paris 1935.

Ibn al-Jazzar : (d1009 Latin Algizar) He flourished at Qairwan, Tunis. He was a famous physician, his popular book was *Zad al-Musafir* (Travelers Provisions) which was translated into Greek, Hebrew into Latin by Constantine Africanus. It contains a remarkable description of smallpox and measles. He also wrote on the cause of the plague in Egypt. His book *Kitab Itimad fee Adwiya al-Mufrada* (Reliable & Simple Drugs) was translated into Latin in 1230.

Ibn al -Qutiyya : (d977) He was born at Seville but made his home in Cordoba. He was a famous historian and grammarian. His *Tarikh al-Andalus* (History of Islamic Spain) deals with Muslim conquest to 893 while his *Tarikh al-Iftah al-Andalus* extends from Muslim

conquest to the reign of Emir Abdur Rahman III. His work on the conjugations of Arabic verbs, Kitab *al-Tasrif al-Afaal* was the first treatise ever composed on the subject.

Menaham ben Saruq: He was a famous philologist**.** His main work is a dictionary of biblical language, the first complete dictionary of its kind. It contained grammatical remarks and other philological information.

Abu Zakariya Yahya ibn Daud: (1095-1165 Avendeath) He was born at Toledo but flourished at Cordoba. He was the father of scientific Hebrew grammar. He wrote in Arabic and his grammar was based on Arabic grammar. To this day the technical terms of Hebrew grammar are translations of corresponding Arabic terms. In translations, only Gerard excelled him. He produced translations of a host of astronomical works of Abu Mashar, Sabit ibn Qurra, Meshallah, and al-Farghani. Turkish writer al-Farabi was his contemporary, he translated his 'On the origin of the Sciences' and 'On the Divisions of Philosophy'. He collaborated with Gundisalvi in various translations, for instance, he turned Ibn Sena's *On the Soul* into Spanish, and Gundisalvi turned it into Latin.

Arib ibn Sad al-Qurtubi: (d976) He flourished at Cordoba at the court of Emir Abdur Rahman III, and Al-Hakam II. He was a famous historian and physician. He wrote a chronicle of Muslim Spain and Africa.
He wrote also a treatise on gynecology, on the hygiene of pregnant women and infants, on obstetrics (i.e. Khalq al Janin – the creation of embryo 964), and a calendar (Kitab al Anwa).

Hasan ibn Juljul : (944-994) This medical historian was born in Cordoba, at age 14 he became deeply interested in medicine. At 24 he was a leading physician of al-Andalus. He composed a commentary on the names of simple drugs given in *Materia Medica* of Dioscorides, a treatise on drugs not mentioned by Dioscorides including those found in Spain, one work on antidotes, and one on the mistakes of physicians. He was a physician to Caliph Hisham II. He wrote a history of the physicians and philosophers of his time in Spain, *Tarikh al -Atiba wal Hukama* (History of Physicians and Wise men) which is the oldest summary in Arabic, on the history of medicine. It contains 57 biographies, 31 are *of* oriental authors, the rest are African and Spanish scholars.
In medicine, his contribution was *Tafsir Asma al-Adwiya*, and *Maqala fi zikr al-Adwiya*. He also corrected and wrote a commentary on the famous translation made by Hasday ben Shaprut.

The following excerpt is from his book **Tabaqata al- Atibba** ," *There is an attractive story about Hippocrates, which we would like to mention in order to show his great virtue. Aflimoon (Polemo) states in his Physiognomy that he can infer a man's character from his constitution. One day Hippocrates pupils assembled and discussed whether they knew of any contemporary more virtuous than the virtuous Hippocrates. They could name none, and somebody had the idea of testing on Hippocrates the claims advanced by Aflimun regarding physiognomy. They had a picture of Hippocrates painted and brought it to Aflimun and asked him politely to look at the individual portrayed and deduce his character from his constitution. He looked at it, compared the individual parts of the body with one another, and pronounced his verdict as follows: "The man here loves fornication." Liar, they said, 'that is a portrait of the wise Hippocrates.' Yet Aflimun insisted his science must be true. 'Ask him yourselves,' he said. 'That man*

would not agree to an untruth'. Thereupon they again went to Hippocrates and told him the story, what they had done, and what Aflimun had told them. Hippocrates replied:' Aflimun is right. I love fornication, but I control myself.' (Tabaqat al-Attiba, Arabic edition Cairo 1955 – The Classical Heritage in Islam, F. Rosenthal, page 254, London, 1975)

Ibn al-Saffar : (d1035) He flourished at Cordoba, retired in Denia. He was a mathematician and an astronomer. He wrote a treatise on the astrolabe and compiled astronomical tables. His treatise on the astrolabe
Kitab al-Amal bil Asturlab was translated by Plato of Tivoli, later translated into Hebrew as well. His father was a coppersmith.

Ibn al-Wafid: (1008- 1075. L Abenguefit). He was a physician of Cordoba who composed a treatise on simple drugs *Kitab al-Adwiya al-Mufrida which he composed in 20 years*, and a treatise on balneology.**(14)** Gerard of Cremona translated his treatise under the title *Liber Medicinarum Simplicium*, printed at Strasbourg in 1531, Vienna 1558.

Sir Thomas Arnold says that the Latin translation was printed some fifty or more times. His book *Kitab al-Wisad* (Book of the Pillow) was translated by Judah ben Nathan. He also wrote an agronomical work, *Majmua al-Filaha*. His book Kitab al-Rashshad fil Tibb (Guide to Medicine) is a manual of therapeutics. His other noteworthy works are *Mujarrabat fil Tibb* (Experiences in Medicine), and *Tadqiq al-Nazar* (Treatment of eye ailments), and *Kitab al-Mugith* (Book of Assistance).
At the demand of the King of Toledo, he planted a botanical garden in the King's orchard.

Ibn Hayyan: (988-1076) He lived in Cordoba, one of the earliest historical writer of Islamic Spain. He wrote 50 books, one of which is the colossal history of Spain, *al-Matin*comprised of sixty volumes. Only one book Kitab al-Muqtabis fi *Tarikh al-Andalus* (biography of Muslim scholars of Spain) in 10 volumes has survived, it was published in Paris in 1937.

Al_Faradi: (962-1013) He was born at Cordoba where he taught. After his pilgrimage to Mecca, he was appointed Cadi of Valencia. Only one of his books, *Tarikh Ulama al-Andalus* was published from Madrid in 1891 by F. Cordera.

Ahmad ibn Muhammad **Al-Razi: (d936)** He was the earliest historian whose work has been transmitted to us. Spaniards called him "el Cronista por Excelencia". His book on history is available in Castilian giving Muslim conquest of Spain, roads, provinces, and cities of al-Andalusia. His ancestors came to Spain from Ray, Iran.

Abul Qasim **Az -Zahrawi: (936-1013, Latin Abulcasis)** He was the greatest surgeon, physician, pharmacist, psychiatrist, of the Middle Ages. He lived at al-Zahra near Cordoba, hence his last name. His literary contribution *Kitab al-Tasrif* is a medical encyclopedia in 30 treatises. It was completed in AD1000 after fifty years of medical practice. In it, he discussed surgery, pharmacy, materia medica, cookery, dietetics, weights, therapeutics, and psychotherapy. He described cataract operation, & methods of preparing drugs by sublimation, and distillation. The surgical part of the book attaches much importance to cauterization and styptics, some sections are devoted to obstetrics and surgical treatment of eyes, ears, teeth. It contains diagrams of more than 30 surgical instruments invented by him.

It describes amputation, dental surgery, wound treatment, crushing stones in the bladder, dissection, vivisection, and fractures. He was the first person to give a description of hemophilia, & used silk thread for stitching of wounds. He prepared teeth from animal bones, laying the foundation of orthodontics. He prepared instruments for internal examination of the ear and inspection of the urethra.

Gerard of Cremona (1114-1187) translated al-Tasrif into Latin as *Liber Servitoris*. The First edition of surgery was published in Venice in 1497, medical part in 1519 Augsburg, the chapter dealing with female diseases published in 1566, then at Strasbourg 1597. Arabic text along with Latin translation by John Channing published at Oxford in 1778, French edition Paris 1861. English edition 'Albucasis on surgery and Instruments' by MS Pink, London 1973.

He says "time plays an important part in the treatment, and cure of disease." He devised new obstetrical forceps. His illustration of surgical instruments is the earliest known intended for use in medical training. He divided man's life span into four stages; early age to 20, youth to 40, maturity to 60, and old age over sixty. He observed that the brain includes three functions of intellect: imagination, thought, and memory. His writings were highly regarded in Europe until the 13th century. Al-Tasrif was part of the medical curriculum in many universities. **(15)**

Ibn Abi Rijal (L. Abenragel-d1040) He was born in Cordoba. His main work in astrology was "Kitab *al-Bari fiAhkam al Nujum*" (The Function of the Stars) which was translated into Castilian, then into Latin in Venice in 1485. Moved to Tunis later in life.

Ibn Sida : (1007-1065) He was born blind in Murcia and died in Denia. He was a lexicographer, philologist, author of a great Arabic dictionary *al-Mukhassas*, which was alphabetically arranged. Another marvelous dictionary *Kitab al-Muhkam wal Muheet alAzam*, was arranged by subject matter: horse, camel, birds, food, women. He gave all the terms known to him. . He had a fantastic memory.

Al-Jayyani: (990-1079) He was born in Cordoba. He excelled in mathematics and astronomy. He wrote *Maqala fi Sharah al-Nisba* (on ratios) and a treatise on *the Total Solar Eclipse*, which is on an eclipse that occurred on July 1, 1079, in Spain. This was translated into Hebrew in 1335, another work *On the Dawn* was translated by Gerhard von Cremona. His book on astronomical tables *Tabulae Jahen* contains instructions for determining the time of day, the direction of prayer, the calendar, visibility of the new moon. Another work on astronomy is *Matrah Shuaa al-Kawakib* (Projection of the rays of Stars). In mathematics, he wrote *Kitab Majhulat Qisiyy al-Kurra* (determination of the magnitude of the Arcs on the Surface of a Sphere) which is available at Escorial library, MS# 955.

Abu Ishaq **Az-Zarqali: (1029-15th Oct. 1087Latin Arzachel)** He was the foremost astronomical observer of his age. He was called *al-Naqash* which means the engraver. He lived in Cordoba. His manual dexterity led him to enter the service of Qazi Ibn Saeed of Toledo as a maker of precision instruments. He constructed the water clocks of Toledo which were in use until 1133. These clocks constituted a precise lunar calendar and were predecessors of the clocks that became fashionable in 17th century Europe.

He constructed an astrolabe *as-Safiha* for observing the sun's movements; it can be seen at Fabra Observatory of Barcelona. An Arabic treatise on this astrolabe demonstrates that al-Zarqali anticipated Kepler in stating that orbits were elliptical. Arabic text states that the orbit of Mercury is *baydi* (oval) in the same way Kepler dealt with Mars in his *Astronomica Nova*. **(16)**

Polish scientist Copernicus (1473-1543) quoted him and expressed his intellectual indebtedness to him in his book *Die Revlutionibus Orbium Celestium*. His astronomical observations were of great value to Copernicus in devising his heliocentric system. Interestingly this Arabic treatise was instrumental in the creation of a new type of technical literature.

He edited the **Toledan Tables**, planetary tables based upon the observations made by him, and a group of astronomers of Toledo. These tables were translated into Latin by Gerard of Cremona and enjoyed much popularity in Europe. It is estimated that 48 manuscripts of these tables are preserved in European universities in Arabic & Latin. His treatise *Rules on the Use of Astronomical Tables* (1070) was also translated by Gerard entitled *Canones.* His introduction to trigonometric tables explains their construction; it was printed from Nuremberg in 1534. He was the first person to calculate the sun's apogee with reference to the stars, as Copernicus later acknowledged in his writings. He wrote a treatise on the movement of fixed stars.

In Toledo in one of the parks of the city, there was a scientific invention called Mansion of the Hours. Al-Zarqali directed the workers to make two large reservoirs. Bu automatic machinery these took 14 days to fill, and then 14 days to empty so that they followed the phases of the moon. The machinery was really cleverly constructed so that if water was poured in beyond the required quantity it was automatically removed**. (17)** He built a clock that could determine the hour of the day and night and days of the lunar month. A surface area of the moon in *Mare Nubium* (sea of clouds) is named after him.

Ibn Gabirol: (1021-1058Latin Avicebron) This original writer-poet, & exegete was born at Malaga. He was the earliest philosopher of Spain, some even called him "the Jewish Plato". His philosophical works exerted a deep influence on Duns Scotus. Gundasalvi rendered his book *Yanbu al-Haya* (Fount of Life) into Latin (Fons Vitae), in collaboration with Ibn Daud in 1150. His other work *Mukhtar al-Jawahir*, (On the Improvement of Moral Qualities) was printed in New York, 1902

Al-Karmani: (d1066) He was born in Cordoba, and died in Saragossa at age 90. He received his education in Harran, Iraq, (now in Turkey). He excelled in mathematics and surgery. He was a disciple of Maslama al-Majriti. It is he who introduced the writings of Brethren of Purity into Spain.

Ibn al-Samh (d 1035). He flourished at Granada. He was a famous mathematician and astronomer. His book, *al-Muamilat* is on commercial arithmetic, while *Hisab al-Hawaii* is on mental calculus, on the nature of numbers. He wrote two books on geometry, two on the astrolabe, its use, and construction. His main work was a compilation of astronomical tables. His Zij was as good as his master al-Majriti's.

Al-Bakri : (1010-1094) He was a renowned geographer and cartographer of the eleventh century who flourished in Cordoba. He was a man of wide-ranging knowledge, a good poet, and a philologist.
His book *al-Masalik wal-Mamalik* (Book of roads and Kingdom) was an outstanding work in geography; De Slane published it in Algiers in 1857. This book was influential in Arabic literature for centuries.
He also wrote a dictionary on ancient geography (*Kitab al Mujam mast-Jama*) of Arabia. This dictionary was edited by a renowned German scholar, Wustenfled at Gottingen, in 1876. A book on principal plants and trees of Andalus is ascribed to him.

Saeed al-Andalusi: (1029-June 16, 1070) He was born in Almeria, later a judge in Toledo. His fame rests on his work in the history of science entitled *Tabaqat ul–Umam* (Classification of Nations) which was extensively used by historians of science. *Tabaqat* was a sort of survey of 11th-century nations who have cultivated knowledge. He lists northern Europeans in the third category of nations that cultivated
sciences. He had a low opinion of their mental traits as well as their physical features. He also wrote a history of learned men, both Muslim and barbarians, and a treatise on astronomy. He was a great observer, his observations were of great value to az-Zarqali.

The following excerpt is from ***Tabaqatul Umam***, French translation by R. Blachere, Paris, 1935. The Arabic text was edited by, L. Cheikho, in 1911.
"*The fourth nation (after the Indians, Persians, and Chaldaeans), that of the Greeks, possessed great importance among the peoples and was very famous in all regions. The language of the Greeks (Yunaniyun) is called Greek. It is one of the richest and most important languages in the world. As to their religion, the Greeks were generally Sabians, that is, worshippers of the stars and idolators.*

Their scholars used to be called philosophers (falasifah). Philosopher (failasuf) means in Greek 'friend of wisdom'. The Greek philosophers belong to the highest class of human beings and to the greatest scholars since they showed a genuine interest in all branches of wisdom, mathematics, logic, natural science, and metaphysics, as well as economics and politics. The Greeks considered five of their philosophers to be the most important. The earliest among them was Empedocles. After he was followed in order Pythagoras, Socrates, Plato, and Aristotle, the son of Nicomachus. "The Classical Heritage in Islam, by Franz Rosenthal, page 38, 1975, London)

Ibn Hazm : (994-1064) He was one of the most original thinkers, elegant writers, poet, biographer, and prominent scholar of the eleventh century. He wrote 400 books on a wide variety of subjects; theology, law, tradition, history, and comparative religion. His fame rests on his work *'al-Fasl fi -Milal wal Ahwal wal-Nihal*" (The decisive word on Sects and Denominations) in which he treated Islam, Judaism, Christianity, and Zoroastrianism. This was the first book on comparative religion in the world.

His prose work was *al-Tawq al-Hamama* (The Ring of the Dove) which is about love and lovers with interesting anecdotes. It is composed in elegant verses, it is preserved in a single manuscript at Leyden. It was written in Jativa (Ar. Shatiba) while he was in prison. Another treatise *Nukat al-Arus* is still extant in a manuscript in Munich. In genealogy, he wrote *Kitab al Jamahar fi ansab al-Mashahir* which deals with the genealogy of Arabs and

Berber tribes. About 36 of his works are still extant. He wrote an epistle defending al-Andalus against the charge of neglecting the biography of its intellectuals.
He had a sharp tongue, therefore he made many enemies. He held some political appointments but politics was not his cup of tea. In his writings his tone was fanatical, he did not show respect for personalities of the past. His character became a proverb in literary circles *'saiful Hajjaj wal Qalam ibn Hazm' (sharp as a sword of Hajjaj and pen of Ibn Hazm.)* This resulted in his books being banned and were seldom quoted. He was charged with heresy, his books were publicly burnt in Seville on orders of Emir al-Mutamid. He was even shunned by students. His other books are *Kitab al-Akhlaq, al-Ahkam, Fisl, Maratib al-Ulum, and Kitab al-Mahallah*. One of his famous quotes is " *My only desire in seeking knowledge was to attain a high scientific ranking in this world and the next.*

The following excerpt is from his book **Maratib al-Uloom**, Arabic edition, Cairo 1954.
"*At all times and in all nations everywhere the sciences have been divided into seven parts. The first three are (1) the science of the religious law as possessed by every nation, (2) the history of the nation concerned, and (3) the science of the language it speaks. The various nations all differ from one another in respect of these three sciences. The remaining four sciences, however, are the same everywhere, namely (4) astronomy, (5) arithmetic, (6) medicine, that is, concern with the human body, and (7) philosophy. Medicine falls into two parts, namely, medicine of the soul and medicine of the body.*

The medicine of the soul is prepared by logic to remove excess and deficiency in ethical matters and to observe the right means, thereby leading to moral improvement. The medicine of the body deals with the humor of the body and the composition of the limbs as well as with an illness, their causes, the medicine with which they can be fought, and the selection of effective medicine and foods." (The Classical Heritage in Islam, page 58)

Ab**u Umar ibn Hajjaj : (C1073)** He flourished in Seville. His treatise on agriculture is al-Maqna (The Sufficient) which was extensively used by ibn al-Awwam. He was a grammarian as well as a botanist.

Abu Bakr **Ibn Bajja: (d1138, Latin Avempace)** This celebrated Andalusian philosopher was born in Saragossa. He was skilled in the practice of mathematical sciences, particularly astronomy and music. He was adept in medicine also. He was a Hafizul Quran. Ibn al-Khatib has described him as the last philosopher of Islamic Spain.
He composed several of his works in Seville in 1118, one of his books on logic is at Escorial Library, # Ar. 609. He then moved to Fez, where he became a minister to Yahya ben Yousuf Tashifin, for twenty years.

He died in 1143 by poison in Fas, Morroco administered to him at the instigation of a jealous physician. Material want and intellectual isolation weighted down his spirits. His original treatise is on the exposition of Aristotle. He acquired proficiency in science, music, and poetry early in his youth, the governor of Saragossa was so much impressed with his verses that he vowed that ibn Bajja should always walk on gold when entering his royal court. Ibn Bajja acceded to his wish and put a gold coin in each of his shoes.

His most famous philosophical works are: *On Soul*, *Tadbir al-Mutawahhid* (the Regimen of the Solitary) and *Risalat al-Wida (the* Farewell Letter), Kitab al-Kaun wal-Fisad, Kitab al-Ittisal, Kitab al-Nafs,

On logic, he wrote: Kitab fil Ism wal Musamma, Kitab fil Burhan. A treatise on astronomy Kitab al-Hindsa wal Haiya. On medicine, he wrote Kitab al-Adwiya al-Mufrida, Kitab al-Tajribtain (a commentary on Ibn Wafid's book), a summary of al-Hawi (Kitab Ikhtisar al-Hawi al-Razi). The Farewell Letter was translated into Hebrew and a manuscript is preserved at Bibliothek Nazionale Paris.

He also authored a Book of Plants (Kitab al-Nabat). Ibn Tofail was his disciple who inspired him in certain works. His treatise on music was much appreciated in the West as al-Farabi's in the East. He played al-Ud and invented many musical tunes, which were popular in al-Andalus.

Long before Galileo or Newton, Ibn Bajja formulated the following theory of motion: " Speed of moving body is equal to the moving force, less the environmental resistance". He also put forward this thesis: "the force that causes a fruit to fall from the tree is the very same as that which moves the celestial bodies." (Burkhardt, page 166, 1972. Moorish Culture in Spain)

In astronomy, he rejected the theory of epicycles as being incompatible with physical doctrine. Thus he seems to have been one of the initiators of the tendency to reject and replace the Ptolemaic system. His criticism of geocentric views inspired Copernicus to form his heliocentric theory. His commentaries on Aristotle's Physics, Zoology, and other works made him best known Aristotelian philosopher of Islamic Spain. One of his famous sayings is " *thought is man's highest function, by thought man attains knowledge of and union with God."*

Yousuf al-Mutamin: (1081- 1085) He was king of Saragossa, a great patron of science. His father Ahmad al-Muqtadir billah (1046-1081) was also a patron of students. Yusuf wrote a mathematical treatise, *Istikmal (* Bringing of Perfection) of which it was said that it should be studied together with Euclid, the Almagest. No copy of this treatise is preserved. **(18)**

Ibn Bassam: (d1147) He composed a literary history of Spain *ad-Dakhira* (the Treasury) which is a treasure house of literary information. His contemporary Ibn Khaqan produced two literary histories, both are distinguished for their prose style.

Abraham bar Hiyya: (d1136) He flourished in Barcelona around 1136. He wrote a number of Hebrew books in mathematics, astronomy & calendar. His most important work was on practical geometry translated into Latin in 1145 by Plato of Tivoli as *Liber Embadorum*. This was the first Hebrew text translated, perhaps the first trigonometry book in the West. It was the earliest exposition of Arab algebra in Europe. In Arabic he was known as Sahib al-Shurta, an elder of the Royal suite, perhaps this was his official title. In his time Barcelona was the hub of Arabic learning and was active in translating masterpieces of Arab science. He was also the author of a mathematical encyclopedia. He played a key role in the creation of science in Hebrew.

He produced a set of astronomical tables *Luhot ha-Nasi (* tables of the Prince), an MS in Latin is at University Library of Cambridge, Hh VI.8, Vol I. He helped in the translation of Arabic scientific works i.e. he worked with Plato of Tivoli on the translation of al-Battani's book in Latin, *De Motu Scientia Stellarum*.

Umayya bin Abdul Aziz abi-Salat: (12th century) He was an eclectic physician and astronomer in the court of King of Denia, Spain. He wrote on philosophy, mathematics, astronomy, and pharmacology, music and medicine. He prepared a summary of Euclid's Elements. All his books are listed in Tabaqatul Atiba.

His treatise on music was translated into Hebrew by Abraham bar Hiyya. His book *Kitab al-Adwiya al-Mufrada* was translated into Latin in 1260 by Villanova. For a while, he lived (1120) in Cairo and Alexandria, where he was thrown in jail due to his failure to remove a sunken ship from the sea. He wrote a treatise Risala Misriya in which he described the archaeology of Egypt, famous physicians, astrologers, and poets he met during his sojourn there. He died in Spain, some of his verses were engraved on his tombstone as he had desired. (Hukamai Islam, by A.S. Nadvi, page 18, Azamgarh, 1956)

Jabir ibn Aflah: (d1150, Latin Geber Filius Afflae) He was a famous astronomer & mathematician of the 12th century who lived in Seville. His masterpiece was *Islah al-Majisti*(Correction of Almajest) the Arabic manuscript of which is preserved at the Berlin Library (MS # 5653). Gerard of Cremona translated it in Latin, it was translated into Hebrew in 1274 by Moses ibn Tibbon. He criticized Ptolemy violently on many astronomical matters. He listed the errors in the prologue. He placed Venus and Mercury above the sun as opposed to Ptolemy. His name was used in Europe as one who criticized Ptolemy. Arabic MS of **"Islah**" is also preserved at Escorial library (# 910 & 930) near Madrid, and in Hebrew at Bodleian Library, Oxford. He used the minaret, *La Giralda*, of the Grand Mosque of Seville for his astronomical observations.

His influence was greatly felt in the West, many writers cited him in their works. Regiomantus in his *De Triangular* (1460) took the core of the fourth book of his treatise from Jabir without acknowledgment. Copernicus called him an "*egregious calumniator of Ptolemy*". His book *Kitab al-Haya* (Book of Astronomy) contains a chapter on spherical trigonometry, which also made a significant contribution to European trigonometry. Michael Scot (d1235) translated this book into Latin *De Astronomia Libri* IX (another title *In Astronomia*), printed at Nuremberg in 1534. The sine theorem was introduced into Spain through *Islah.* A Ph.D. dissertation 'Jaber and his influence in the West' by R.P.Lorch was submitted to the University of Manchester, the UK in 1970.

Al-Ghafiqi: (d1165) He was a physician in Cordoba. His interest mostly was in botany. His book on the collection of plants of Spain & North Africa is considered to be the most accurate and precise in classical Arabic literature. *Adwiya al-Mufradah* contains the names of plants in Arabic, Latin, and Berber.

Abraham ben Azra: (1092-1167) He was a famous Jewish grammarian, poet, philosopher, and exegete. He was a distinguished Biblical commentator who translated al-Biruni's commentary on Khwarizmi's (Zij al-Sindhind) astronomical tables. His wanderings in various countries Egypt, Italy, France, and England did not hinder his composing scientific

works. He was the first Spanish to write in Hebrew. In arithmetic, his famous work is *Sefer ha-Mispar,* while *Kele ha-Nesoshet* (The Copper Instrument) is on the astrolabe. He wrote three works on arithmetic, and three on the theory of numbers in addition to preparing astronomical tables.

Abu Hamid al-Gharnati: (1080-1169) He was a talented geographer, loved traveling into distant lands. He migrated to Egypt, visited Baghdad, Persia, and went up the river Volga. He wrote two books, Murib *an bad ajaib al-Maghrib* (an anthology of the marvels of the Maghrib), and *Tuhfatul al-Albab* (Gift from the Heart). The first book contains a long dissertation on astronomical, astrological matters besides describing some of the marvels of Islamic Spain. The book also contains the oldest description of skis used by the people in the Arctic, complete with a diagram. The description of flora and fauna of northern Russia is also of interest.

Abu Abdulla **al-Idrisi: (1000-1166)** He was born in Ceuta, but received his education in Cordoba. After visiting Spain, North Africa, and Asia Minor he settled in Sicily. He was the greatest geographer of the Middle Ages. For King of Sicily, Roger II (1130-1154) he made a celestial globe and a disk shape map in silver showing seven zones of the world. He was commissioned by the King to write the geography of the world.

This work is entitled *Nuzhat al-Mushtaq fee Ikhtiraq al-Afaq*(or Kitab al-Rujjar, a book of Roger). It was illustrated with 70 maps. He did his work at Palermo, the aforementioned book shows his grasp of such fundamental facts as sphericity of the earth. This doctrine was crucial to the discovery of America. A synopsis of the text with 71 maps was printed in Rome in 1592. Partial editions of the text have been made in Leyden, Rome, and Bonn.

Abu Bakr **Ibn Zuhr: (1091-1162 Latin Avenzoar)** He was born in Seville where he became court physician of Caliph Abd al-Momin (d1163). He belonged to a family of gifted scholars, viziers, and generations of physicians. He dedicated two of his treatises on medicine *al-Tiryaq al-Sabini* and another one on diet *al-Aghziyya* to emir Momin. He dedicated his book *al-Tadhkira* happily to his physician son who took such good care of his patients while he was away. The book deals with fevers, therapeutics, and careful use of a laxative. He published an elaborate Pharmacopoeia for his students in Cordoba.

He developed many original ideas. He discussed the value of good diets, antidotes against poison, the use of purgative in treating the sick, tumors, paralysis of the pharynx, scabies, inflammation of the middle ear. He also recommended artificial feeding through the rectum, the use of cold water to reduce fever, and the use of clean air for health. His other books are *Fi Ilal al-Kila (* kidney disease), *fi Illatay al-Baras wal-Bahaq* (leprosy & vitilego*) al-Tadhkira* (treatment of disease), *Jami Asrar al-Tibb* (secrets of healing art) a copy is available at the National Library of Rabat, Morroco. A 14th century MS of al-Aghziyya is stored at Suleimaniya Library, Istanbul.

He authored six medical books. The most valuable work is his magnum opus, "al-*Taysir" in* 30 treatises, written at the behest of his friend Ibn Rushd who copied it. In **Colliget** Ibn Rushd described him as the greatest physician since Galen. He was the first person to discuss feelings in the bones and gave a clear description of itch mite. Gerard of Cremona

translated *al-Taysir* into Latin, published in 1280 entitled *Theisir*, and was used as a textbook in medical universities of Montpellier and Bologna. **(19)**

Abu Bakr **Ibn Tofail: (1105- 1185 Latin Abubacer) He** was born in the town of Guadix, and died in Morocco. He was also known by the name Abu Jafar. He was fond of books than of men. He read all the books available in the Caliph's library. He was given to contemplative enjoyment than scientific work. He was an outstanding physician, mathematician, & philosopher. He was a pupil of Ibn Bajja.

He composed verses but wrote very rarely. He was actively engaged in medicine and politics during his stay in Granada. He was appointed judge, a minister in Seville, and later became the personal physician of Caliph Abu Yakoob Yusuf (1163-1184). He attracted leading scholars of Al-Andalus to the royal court; Ibn Rushd was one of them. On his advice, Ibn Rush became interested in Aristotle's works.

His masterpiece *Hayya ibn Yaqzan* (Living One, son of the Awake) earned him a niche in the temple of universal literature. It was one of the most remarkable works of the Middle Ages. In 1349 it was translated into Hebrew with commentary. The Arabic text with Latin translation *(Philosophus Autodidactus*) by E. Pococke was published at Oxford in 1671. G. KEITH rendered it into English in 1674.

The Arabic original has been frequently published from Cairo and Istanbul. It has been translated into Spanish, Dutch, German, Urdu, and Russian also. (Encyclopedia of Religion and Ethics, Vol 7, 1928, James Hastings) It has been suggested that the original of Daniel Defoe's *Robinson Crusoe* written in 1719 was this book. German philosopher Leibniz knew Ibn Tofail through Latin translation of this book.
Ibn al-Nafees (d1288) the Syrian doctor who gave the earliest known account of pulmonary blood circulation wrote a counterpart to Hayee ibn Yaqzan. He died in Morocco.

Noor al-Din **Al-Bitruji: (d1204, Latin Albetragius)** He was a leading astronomer of his time**.** He was born in Morocco, migrated to Spain, and settled in Seville. **As** an able pupil of Ibn Tofail, he had original ideas on the movements of the planets. He put forth a new theory regarding the movements of the stars. His book *Kitab al-Haia (Book of Form)*, was translated into Latin ' *De Motibus Celorum Circularibus',* by Michael Scot, in 1217 at Toledo, reprinted at Berkeley in 1952. His theory of motion was introduced into Europe through this Latin version. This was translated into Hebrew, by Moses ibn Tibbon, printed in Vienna in 1531.

Al-Bitruji did not trust the human senses, given the distance between the observer and the spheres, and put his faith in human reason. His astronomical system exerted a deep influence on European scholars from the thirteenth century down to the time of Copernicus (1473-1543). Grosseteste (d1253) referred to it in his works, even plagiarizing from it in his refutation of the Ptolemaic system. Albert Magnus spread his ideas in simplified form. Roger Bacon expounded his astronomical system in detail. In his work *Opus Majus*, Bacon discussed al-Bitruji's theory of tides. His ideas continued to diffuse in the 15th and 16th centuries. Copernicus cited his system in his book *Die Revolutionibus*, in connection with the theories of the order of the inferior planets. A surface area of the moon in *Mare Nectarus* is named after him.

English translation with the Arabic text of Kitab al-Haya was edited by Goldstein entitled *al-Bitruji*: *On principles of Astronomy.* ***(20)***

Ibn Rushd: (1126-1198 Latin Averroes) He was the greatest philosopher and physician of Spain who was born in Cordoba in an illustrious family. He was appointed a Qazi in Cordoba & Seville, a position of dignity second only to the Caliph. He became the personal physician of the Caliph Abu Yakub Yusuf. He was a friend of Ibn Tofail. At a young age, he became well-versed in Greek sciences. He wrote 38 commentaries on various works of Aristotle, for this he was called *The Commentator*. He usually wrote a short **(Jami**), a medium (**Talkhis,** resume), and a large commentary (**Sharh).** His writings became prescribed studies at the University of Paris.

The intellectual movement started by him remained a living factor in European thought until the 17th century. In 1230 his commentaries were repeatedly translated into Hebrew and Latin which made Cordoba Athens of the West. **(Arab Capital Cities of Islam, page 160**) The school of understanding Aristotle through him is known as Averroism. He was a disciple and friend of Ibn Zuhr.

He wrote on astronomy, physics, and medicine also. His book *Kulliyat fi Tibb* (General Rules of Medicine) was translated into Latin (*Colliget)* by Bancosa in 1255 in Padua, and enjoyed widespread reputation (printed editions Vienna 1496, Augsburg 1519, Arabic text with Latin Oxford 1778, French 1861). In this book, he described the real function of the retina as a photoreceptor (receiving the image and transmitting it to the brain). He also stated that smallpox leaves immunity in those who are afflicted with it. The book deals with anatomy, drugs, foods, physiology, disease, and its symptoms. He wrote a total of sixteen works in medicine.

His book *Tahaftul Tahafah* (Incoherence of Incoherence) was a refutation of Imam al-Ghazali's 'Tahaftul Filasfa', paragraph by paragraph, expounding the beliefs in the ability of reason to understand the secrets of the universe. It was translated into Latin in 1328. In 1188 he completed a book on Islamic jurisprudence dealing with differences between Muslim schools and arguments used by each to justify their positions.

He fell from Caliph's grace when Ulema, after a solemn inquisition, declared him a heretic (zendik) because of his beliefs in eternity, predestination, and resurrection of the body. His books were publicly burnt in Seville, and he was banished from the city. He exiled to a small place Lucena, near Cordoba. In 1195 Caliph Abu Yakub's son al-Mansoor ordered his books to be burned except his treatises on medicine, arithmetic, and astronomy.

The decree was later reversed by Almohade Caliph of Seville, Yakoob bin Yousuf (1186-1197) but he did not enjoy his return to grace, dying on 11th December 1198 in Morroco. His Arabic commentaries (*Jawami)* are preserved in Madrid's Escorial library. His writings deeply influenced Christian as well as Jewish scholars until the sixteenth century.

English scholar Burke is of the view that *" the great Muslim whose translations and speculation were the seed whose fruit was the reformation of Christendom was almost without influence in Islam*" (History of Spain, Burke, 1894, page 209) Ernest Renan, the French scholar of

19th century wrote much about him and William James in *Principles of Psychology* has supported some of his views.
His commentaries opened the treasure-house of Greek learning to the students of medieval Europe.

Ibn Maymoon: (1135-1204 L. Maimonides) He was born at Cordoba, received his education from his father and Muslim teachers. At age 13 he left Spain and after wandering around in Morocco & Palestine he settled in 1155 in Cairo. He was the most illustrious physician and thinker of Jewish history. He wrote several works in medicine and philosophy, all in Arabic. *Dalalat al-Hairin*, Guide for the Perplexed is his masterpiece that was translated into English in 1884 by Friedlander. His important treatise *Maqala Fee Tawhid* is on the unity of God. He was the personal physician of Sultan Salahuddin Ayubi. In Cairo he held several public offices but never took any remuneration, he made his living through medical practice.
Ibn Jubayr: (1145-1219) This distinguished geographer was born in Valencia, he made three trips to Mecca and Medina. He recorded his impressions of cities in Iraq, Egypt, Syria, and Sicily in a diary, which was later published as *Rihlah* (Travel). His opinion was impartial, read this brief quotation,"*To the east of Acre, on the side of the mainland, there is a valley in which river flows, and between the river and the sea, there is the most beautiful plain of fine sand that can be seen anywhere. There is no racecourse that can be compared with it. On Saturday (October 6) we embarked upon our vessel, once embarked, trusting in the will of Allah, we waited for a favorable wind & for the vessel to complete its cargo". Ibn Jubair's account of his journey through Syria in 1184.* ***(21)***

Ibn al-Arabi: (1165-July 23, 1240) He was born in Murcia, studied in North Africa and al-Andalus. In 1201 he went for pilgrimage and spent the rest of his life in Mecca, Baghdad, and Damascus. Mohiyuddin ibnul al-Arabi was the greatest mystical writer of the Middle Ages, with a vast literary output of 251 works. In his book *Tartib al-Rihlah* (The Itinerary of a Journey) he described his meeting with notable teachers and scholars. His tomb is enshrined in a mosque in Damascus.

To his followers, he was **al-Shaykh al -Akbar** (Grand Master). His other noteworthy works are *Futuhat al-Makkiya (The Revelations of Mecca), Fusus al-Hikam (Bezels of Divine Wisdom), Tarjuman al-Ashwaq,* (love poems translated by R.A. Nicholson in 1911, London) and *al-Diwan al-Akbar* (collection of mystical poems). Of this huge corpus, only 71 have been printed, 33 commented upon and 16 translated into various languages. (Martin Lings, Sufis of Andalusia, 1971, Page 47). One of his famous disciples was the famous astronomer of Iran Sadrudin Sherazi. He inspired many medieval Christian writers.

He was the greatest genius of Islamic Sufism who saw Prophet Muhammad (SAW) in a vision. One of his beautiful sayings: **God is unity. The unity of love, of the lover and, the beloved. Every love is a wish for the union. Every love consciously or unconsciously is love for God.**

The following excerpt explains the wonders of light: " *If it were not for the Light, nothing at all could be apprehended by the mind or the senses or the imagination, and the name given to the light, varies with the faculties, which we also call by different names. According to the common folk, the name is given to the*

mind, and among the gnostics, to the light of perception; when you apprehend what is audible, you call the light which apprehends, hearing, and when you apprehend what is visible, you call the light seeing. Light involves a relationship, for apprehending what is apparent. Everyone who perceives must have some relationship to the light, by which he is made able to perceive, and everything which is perceived has a relationship with God, Who is Light, that is, all which perceives and all which is *perceived".* (Margaret Smith, Readings from the Mystics of Islam, London 1950, pp97-101)

Ibn Baytar: (1197-1270) He was born at Malaga. He was the greatest botanist & pharmacist of the Middle Ages. As a keen student of botany, he learned from observation and experimentation. In 1219 he left Spain on a plant collecting expedition and traveled to Arabia, Syria, and Iraq where he continued the study of plants. Among his students was outstanding historian Ibn abi Usaiba, author of a history of 600 physicians. He died in Damascus.

His work *al-Jami al-Mufridat al-Adwiya wal-Aghziya* (Collection of simple drugs and foods, Cairo 1291 AH) is arranged alphabetically. He mentioned 150 Greek and Islamic authors and corrected their mistakes. Some 1400 plants and minerals are described, of which 300 were novelties. In Latin, this book was published as late as 1758 from Italy. This is a work of extraordinary observation; in fact the greatest book in Arabic in botany.

Ibn al-Banna: (1256-1321) He was a native of Granada. He taught arithmetic, algebra, geometry, and astronomy in the madrassa at Fez, Morocco. He wrote approximately 82 works including an introduction to Euclid, a treatise on algebra, a book on astronomy *'Kitab al-Anwa',* another one '*Minhaj',* and an almanac. His book *Talkhis* is a summary of the lost work of 12th-century mathematician al-Hassar. He wrote a risala (treatise) on the astrolabe called *'Safiha Shakaziyya'*.

Ibn Khaldun: (1332-1406) He was the greatest Arab historian of all time. He was born in Tunis where his family had moved from Seville, Spain. He lived in Granada (1362-1365) during which time he took a diplomatic mission to Christian Seville. Here he started work on his celebrated book *Kitab al-Ibar* (History of the World) and completed its *Muqaddama*(Introduction) in 1377. He returned to Tunis to complete this monumental work. In Egypt, he became a professor and administrator at al-Azhar university. In 1387 he performed Hajj and in 1401 he met Mongol conqueror Tamarlene in Damascus. He died in Cairo on 17th March 1406. He is considered to be the founder of the science of sociology.

Lisanu din ibn al-Khatib: (1313-1374) He was an outstanding literary figure of the 14th century. He penned some sixty works on history, geography, medicine, and philosophy. He authored a very useful biographical dictionary, composed of odes and muwashahs (folk songs), an urjuza (poem) entitled *'Raqm al-Hulal fi nazm ad-Duwal'* describing the history of Islam in Spain. His history of Granada *al-Ihatah fi Tarikh* ***al–****Gharnatah* was published from Cairo in 1319 in 2 volumes. In the kingdom of Granada, he held the title of *zul-wazaratayn*, i.e. a political vizier & vizier of the pen. His book ***al-Yusufi*** in 2 volumes was a standard work in medicine. He was the last scholar of Islamic Spain, after his death interest in sciences vanished.

His works constitute one of the earliest encyclopedias in the world of letters.

Christians regarded the plague (Blackheath) that ravaged Europe during the 14th century as divine punishment. However, ibn- al-Khatib described the epidemic as a contagion in his treatise **'On Plague',** boldly stating in the face of Christian orthodoxy, " *the fact of infection becomes clear to the investigator who notices how he who establishes contact with the afflicted gets the disease, whereas he who is not in contact remains safe, and how transmission is effected through garments, vessels, and ear-rings".* **(22)**

Abul Hassan al-Qalasadi : (1412-1486): He was born in Basta (now Baza) and died in Beja, Tunisia. He was best known for his advances in arithmetic and algebra. He was the last known Spanish Muslim mathematician. Several books are attributed to him, the one on algebra is a commentary on the al-Urjuza al-Yasminiyya of ibn Yasmini (d1204) which gave algebraic rules in verse. One of his arithmetical work is a commentary on the *TALKHIS amal al-Hisab* of ibn al-Banna. His original works are al-Tabsira fi ilm al-Hisab (Classification of the science of Arithmetic) and Kashf al-Jilbab an ilm al-Hisan (Unveiling the science of Arithmetic). These books were used in schools in North Africa for centuries.

He is credited with using symbols in algebraic equations and finding square roots by successive approximation. He used short Arabic words and letters as symbols**. WA** (and for addition **ILLA (**less, subtraction), **FEE (**times, for multiplication), **ALA (**over, for division). He used the following letters J(Hazar root), SH (Shaye, thing for X), M (mal, X2), K(for Kaab X3), MM (for X4).

Technology in Islamic Spain

The above list gives ample evidence of the fact that Muslim scholars in Spain were great scientists, physicists, astronomers, mathematicians, and geographers. A number of them devoted their lives to scholarly pursuits in adverse circumstances. As science and technology go hand in hand, we will now give a general overview of the development of technology in al-Andalusia.

During the middle ages, technology flowed from far-off countries of China, India, and Persia to Europe through Islamic countries. For example, the paper was first manufactured in Samarcand, it was brought to Islamic Spain in the 10th century. Al-Andalus was good at making scales (MIZAN) and weights, hence these were exported to Morocco. France was completely dependent on Islamic Spain for textiles, both for style and techniques. Water shortage spurred the diffusion of hydraulic devices. Water was brought in lead pipes from the mountains to be distributed in the cities. Spanish Muslims loved the water, every mansion was equipped with running water and fountains. Abdur Rahman III constructed a scientifically designed aqueduct, in 940 over the arches on the river Guadalquivir (*Wadi al-Kabir*). Water was then conveyed with pipes to waterworks in Cordoba.
In agriculture, Muslims introduced scientific methods of irrigation. Production of olive oil increased to such a degree that Europeans adopted the Arabic terminology for most of the instruments used.

A**lmazara**, oil press (Ar. Misara)- **Alfarje,** grinding stone (Ar. Farsh)- **Alcuza,** oil can (Ar. Kuza)- **Setrill,** olive oil (Ar. Zait).

Crystal was discovered in the glass workshops of Cordoba. Glass vessels were blown in Malaga, Murcia, Almeria, there was a flourishing glass industry also in Barcelona. *'Glass of Damascus'* referred to Syrian style enameled glass. Valencia (*Balnasiyya)* was the home of exquisite pottery, Jaen (*Jayyan)* was noted for its mines of gold and silver, Cordoba for iron and lead, Malaga (*Malaka*) for mines of rubies, and Toledo (Tolaytla) for its swords. There were 3000 villages devoted to rearing silkworms; Seville was the center of silk weaving.

European paper mills were first established in Islamic Spain. There were Muslims with the last name al-Waraq – the papermaker. Paper was made from flax fibers (old scrap clothes) soaked in quicklime, washed, pounded, and dried in molds. At the one-time gathering, rags for the paper industry was a profession. Jativa *(Shatiba*) was the first center of this industry in Spain & Europe, its product was called **Shatibi.**

During the 13th century, the paper was exported to Sicily from the cities of Barcelona and Valencia. **Mechanical printing was the reason for the widespread dissemination of knowledge in Europe, thanks largely to this industry in Islamic Spain. Paper was one of the best contributions of Islamic Spain to Europe.** Paper mills came to France via Spain. English word ream is derived from Arabic rizma, a bundle. (23)

The textile was another industry in which Islamic Spain made a lasting impact on Europe. Port cities of Malaga and Almeria were famous for producing **Tiraz** (brocade), silk cloth embroidered with Arabic lettering. Tiraz was a state-sponsored industry run by trained weavers, the training school was called Dar al-Tiraz. Tiraz material was used for making costumes of military commanders, officials, & Caliphs. Isfahani cloth and attabi fabric were also produced in large quantities.

Attabi was a silk & cotton fabric named after a district of Baghdad where it originated. It was popular in European shops by the trade name of ***tabis.*** Dress fabrics from Grenada were known as '***Grenadines***' in European markets. 16

Tanning techniques produced a number of soft leathers in Spain. Cordoban (*Cordwain*) was vegetable tanned goatskin. Ivory was carved in Cuenca and many other towns. Ivories painted with Arabic inscriptions were also produced in many cities. In the 10th century, a school of ivory-carvers centered at Cordoba was working in a style that proclaims mature experience. Amongst the extant examples of their work is the cylindrical casket made for Caliph al-Hakam II in 964, at display in the Museo Archeologico, Madrid. **(24)** Pottery was manufactured for Popes, cardinals, and the rich families of Portugal, France, and Italy. Valencia was the center of painted drug-jars. Spanish lustered pottery inspired Italians potters in the 16th century.

The terminology for net fishing is laced with Arabic words: aljerife (dragnet), almadraba (tuna trap), Atarayya (conical net), Jareta (purse seine), Jabega (pocket seine). Clocks were in use in many forms. The sundial was used with a table of declination of the sun. A clepsydra was a water clock in which water flow was regulated by a siphon. A mercury clock used an astrolabe for dials, mercury flowed from compartment to compartment keeping it in perpetual motion, the astrolabe dial rotated once every 24 hours. Water clocks were built in Toledo by al-Zarqali. **(25)**

Astrolabe – a computer

The astrolabe was an astronomical instrument made of brass. It served as a sort of computer for nearly a thousand years. It provided data for calculating latitude, determining time, surveying, nautical observation, and the casting of horoscopes. Muslim interest in this instrument was immense due to the fact that they could determine the hour of canonical prayer, the direction of Mecca, and the beginning of new months. It was introduced in Europe in the 10th century by Gerbert (later Pope Sylvester II 999) who learned its use during his sojourn in Cordoba. It was used in Europe until the 16thcentury for nautical observation. Every astronomer whether Jewish, Christian, or Muslim used it. "*How to Use*" manuals were written in Arabic, Hebrew, and Latin. The earliest such manual was written by Mashallah in Iraq around 800AD.

In al-Andalus, Hasday ibn Shaprut obtained Mashallahs treatise on Astrolabe (*Ar. Asturlab*) that became the basis of all future treatises. Maslama al-Majriti wrote a treatise that was translated by John of Seville in the 12th century. There is an astrolabe at Oxford Museum dated 984 made by Ahmad ibn Ibrahim of Isphahan, Iran. The astrolabe used by Chaucer can be seen at Merton College Library, Oxford.

One made by **Ibrahim ibn Saeed at Toledo in 1066** can be seen at Victoria & Albert Museum, London. One made by the Muslim instrument maker of Valencia is at, Smithsonian Institution, National Museum of American History, Independence Ave, Washington, USA. The description of *as-Safiha*astrolabe made by Al-Zarqali was widely read in the 13th century in Castilian. Portuguese explorer Vasco da Gama's ships were fitted out with astrolabes designed by a Spanish astronomer**. (26)**

Astronomical tables were used to find out eclipses, planetary motion, and trigonometric functions. Islamic Spain is best remembered for *Toledan Tables* produced by al-Zarqali. Christopher Columbus (1446-1506) carried a copy of astronomical tables prepared by Abraham Zacuto (1452-1515) during his voyages to the New World. Columbus fully expected to land in India, which he knew was ruled by Muslims, hence on his first voyage to America, he took with him Luis de Torres, an Arabic-speaking Spaniard as his interpreter. In a nutshell, the emergence of modern science in Europe owes a great deal to advancements in science in Islamic Spain.

About the author: Zakaria Virk was born in India in 1946. He did his law degree from the University of Karachi. After studying for 3 years in Gottingen, Germany he moved to Canada in 1973. He has authored, compiled, translated 16 books in Urdu/English. His son Adnan Virk is an anchor at ESPN, USA. He lives in Maple, Ontario with his wife. He can be reached at Zakaria.virk@gmail.com

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