# Muslim Contributions to Sciences

**Mathematics, Astronomy, Geography, Chemistry, Physics, Medicine, Optics, Pharmacy, Opthalmology, Algebra, Zoology**


**By**
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## DEDICATION

I dedicate this book to my loving mother Zainab Bibi who died in 1949 when I was only three years old. Although I have missed her all my life, but in my old age, I miss her tremendously. Her memory has always been burning in my heart like a candle. Fortunate are those who have their mothers, this is my biggest loss and misfortune.

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# ABOUT THE AUTHOR

ZAKARIA VIRK (1946- ) is a Canadian author, historian of science, and journalist. He has written scores of articles in English and Urdu which have been published in renowned journals and newspapers of India, Pakistan, UK, USA and Canada. He is editor for Canada for *The Muslim Times*, USA. He is member of editorial board of *Qindeel-e-adab*, a mothly journal published from London. He is also a member of consulting board of a journal *Mujalla Tarikh wa Saqafate Pakistan*, Quaid-i-Azam University, Islamabad. He was taken part in essay competitions and won awards.

He has authored, translated, and compiled 19 books, five of which are on the eventful life and glorious achievements of Nobel Laureate Prof. Abdus Salam. His forthcoming book '*Tilsam Insani Jism*- wonders of the human body' is under print from India, due August 2017.

All his English articles are available at https://karachi.academia.edu/ZakariaVirk. Some of his books are available at apnaorg.com (USA) as well as alislam.org (UK). ICTP Theoretical Centre Italy, https://salam.ictp.it/salam/bibliography/biographies, USA library of congress https://catalog.loc.gov/

**His books**:

(Urdu) 1. Azeem Zindagi, 2.Ramooze-fitrat, 3.Nishan-e-manzil, 4.Musalmano ka Newton (life of Dr. Abdus Salam), 5.Muslamano kay science karnamay Aligarh, 6. Biography of Ibn Rushd Aligarh, 7. Biography of al-Biruni New Delhi, 8. Summary of J.D. Bernal book 'science in history', 9. Urdu Translation of '*Salman Rushdie Haunted by his unholy ghosts'*, 10. Hukamaye Islam -Delhi, 11. Zikray Abdus Salam India, 12. Musalmano kay science karnamay- expanded edition New Delhi, 13. 111 Muslim sciencedan, Lahore & Varanasi India, 14. Salaam Abdus Salam, India. 15. Tilsam Insani Jism – Wonders of the Human Body, Varanasi, India.

(English): 16. Translation from Urdu: A Brief history of Ahmadiyya Muslim Jamaat, 17. *Scientist of the Eas*t – Dr Abdus Salam, 18. Translation from Urdu: Translators and commentators of *Qanun ibn Sena*, By Padam Shri Prof Dr. Syed Zillur Rahman, Aligarh. 19. *Muslim Contributions to Scieces*. 20. Currently working on '*Islamic Quiz*' 510 questions and answer about Islam, Quran, Hadith, & Islamic history.

Chapter 1

# Muslim Contributions to Ophthalmology

Science progressed at an impressive pace in the Muslim world during the Islamic golden age i.e. from 8th to 12th century. Not only voluminous & insightful books were composed on various scientific disciplines but new inventions and ground breaking discoveries were made. Of the various medical disciplines, most of the contributions were made by medical practitioners in the field of ophthalmology.


Eyes are windows to your soul

Ophthalmology is the branch of medicine that deals with the anatomy, physiology and diseases of the eye including the eye, brain, and areas surrounding the eye, such as the lacrimal system and eyelids. An eye specialist is known in Arabic as Al-Kahhal from the word *Kuhl* (kollyre).

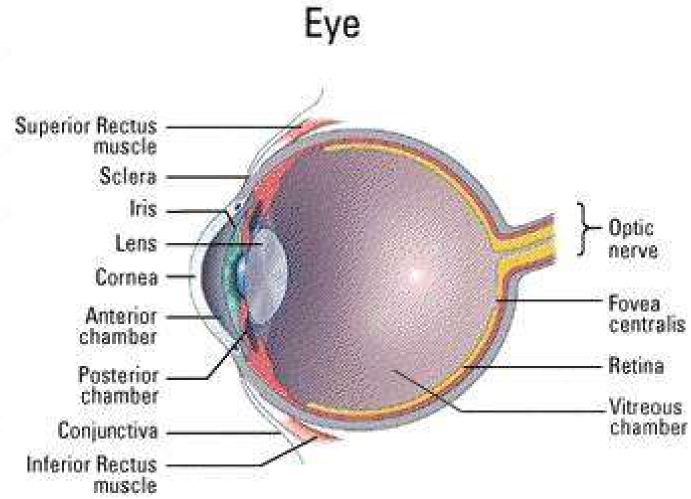
Renowned Muslim scholars like Zakariya al-Razi, Ibn Sena, al-Haytham, al-Zahrawi, Ibn Zuhr, Ibn Rushd, Ibn Nafis made significant contributions in this field. Books authored by Al-Razi, Ibn Sena, & al-Zahrawai were used as medical text books in European universities for centuries. In the main hall of the Paris University's Faculty of Medicine, there hang portraits of al-Razi and Ibn Sena as a tribute to these two giants of medicine. On the stained glass window pane of a church in Princeton University, al-Razi portrait is painted as acknowledgment to his skill and immense benefits of his skill & knowledge to humanity.

The way science is divided these days into various branches, this was not the case during the middle ages. I have yet to see curriculum of medical schools. To become a practitioner there was no fixed path. All one had to do was study medical books and get training under a seasoned physician. To become an ophthalmologist a license was required granted by Hakim-bashi, royal physician to the Caliph. Before 931 there was no medical certification, when Caliph al-Muqtadir asked Sinan ibn Sabit to examine and approve physicians. Ophthalmologists hence had to satisfy the examiner that they knew the principal diseases of the eye as well as their intricate complications, and were able to properly prepare collyria and ophthalmic ointments. Moreover they had to assert under oath not to allow unauthorized persons access to any surgical instruments, such as the lancet that was used for cases of pannus and pterygium, or the curette used for cases of trachoma. Compared to a physician, eye doctor fee was small.

Muslim physicians-oculists made astonishing contributions and discoveries in eye diseases and cures. It was a Muslim scholar who produced anatomy of the eye for the first time. The Latin word "*retina*" is derived from Avicenna's Arabic term for the organ. The "injection syringe", a hollow needle, was invented by Ammar ibn Ali of Mosul, Iraq. Al Mosuli attempted the earliest extraction of cataracts using suction. Eye conditions such as pannus, glaucoma (described as 'headache of the pupil'), phlyctenulae, and operations on the conjunctiva were described by Muslim physicians/oculists. Ibn Rushd (1198) was the first to attribute photoreceptor properties to the retina. [1]

[1] Zakaria Virk, Biography of Ibn Rushd (Urdu) Aligarh Muslim University, India 2007

Arabic terms such as Eyeball, Conjunctiva, Cornea, Uvea and Retina were introduced by Muslims. Muslims also did operations on diseases of the lids such as trachoma, a hardening of the inside of the lid. Glaucoma (an increase in the intra-ocular pressure of the eye) under the name of "Headache of the pupil" was first described by a Muslim.




Muslim physicians/ oculists made significant contributions in ophthalmology: Yuhanna ibn Masawayh, al-Tabari, Ali ibn Abbas al-Majusi (994), a-Zahrawi (1013) Ammar bin Ali al-Mosuli, Hunayn ibn Ishaq (a Christian), Ali ibn Isa, al-Razi, Ibn Sena, Ibn al-Haytham (1039) Abu Abdulla al-Tamini, Adnan al-aynzarbi (12th century), al-Ghafiqi, Ibn Rushd, Khalifa abi al-Mahasin, Fatah al-Din al-Qaysi, Ibn al-Quff al-Karki, ibn Nafis, Daud al-Antaki (1599), Ibrahim al-Hanafi, Abd al-Qadir al-Khulasi al-Dimishqi, Ahmad Hassan al-Rashidi (1840).

Translations of more than 400 Arab authors, writing on such varied topics as ophthalmology, surgery, pharmaceuticals, child care and public health, deeply influenced the rebirth of European science. Works of the Muslim ophthalmologists were translated into Latin and became the foundation of the ophthalmology in Europe, with many Arabic texts used well into the nineteenth century.

**Hunyan ibn Isha**q (873 Baghdad) was the first one to provide anatomy of the eye in his ground breaking work *Kitab al-ashr maqalat fil Ayn* – i.e. Ten Treatises on the Eye. His detailed explanations of the physiology of the eye, reached Europe during the Renaissance and carried many terms still used today, based upon the Arabic words. European scholars gave diagrams of the eye made by Hunayn. He described cysts, tumors and ulcers, their causes and also laying out recommended treatments and suggestions for repairing cataracts.

**Abu Bakr Muhammad Ibn Zakariya al-**Razi (923 Iran/Baghdad) was known in Medieval Europe by the title of *The Arab Galen*. He was the first one to state retina reacts to light. Also he was the first doctor to describe the reflex action of the pupil. In his treatise *On the Nature of Vision* he stated eyes do not emit rays of light, as the Greek scholars had thought. In his landmark book *Kitab al-Mansuri*, Razi documented the removal of cataracts with a glass tube and described the cauterization of lachrymal fistulas, truly innovative work in the field. His treatise on ophthalmology was translated into German in 1900. In his magnum opus *Kitab al-Havi* there is a chapter on ophthalmology. He explained causes for glaucoma i.e. salt consumption. His other books in this field are *fee kaifiyat al-absar, kitab fee hait-al ayn, kitab fee elaj al-ayn bil-hadid.* [2]

There are some sections in *Kitab al-Mansuri* that deal with anatomy of the eye and eye ailments. *H*e observed how airborne germs can cause infectious diseases, including inflammation of the eye: "*Among the things that are infectious are: leprosy, scabies, consumption and epidemic fever, when one sits with those who are afflicted in small houses and downwind (from them). Often ophthalmia infects by being looked at and often (the condition of) multiple evil ulcers is (also) transferable. Generally speaking in every illness which has decomposition and (bad)*

[2] https://www.academia.edu/9716612/Abu_Bakr_al-Razi_-_The_Arab_Galen

*air, one should distance oneself from the afflicted or sit upwind from them*.[3] His essay on infectious diseases was the first scientific treatise on the subject. His originality is evident in his veritable clinical observations.[4]

The earliest known medical description of the eye, from a ninth-century work by Hunayn ibn Ishaq, is shown in this copy of a 12th-century manuscript at the Institute for the History Arab-Islamic Science in Frankfurt.

**Abu Mansur al-Hassan al-Qumri** (990) lived in Khorasan, Iran. He was teacher of Ibn Sina. His only treatise *Kitab al-Ghina wa-al Muna* is preserved in NLH, USA. He explained reasons for weak eyesight namely: such a person had constipation, looked at a bright object, read books with small letters, consumed too much salt in food, or had too much sugar for a prolonged period. Now a day it is called diabetic retinopathy.

Al-Qumri's Kitab al-Ghina wal-Mina, this page explains treatment of trachoma (al-jarab in Arabic). http://www.nlm.nih.gov/hmd/arabic/E7.html.....

**Abul Hassan Muhammad bin Tabari (10th century)** his book Mu'alijat al-Buqratiyya contains 10 dissertations, 4th one is on diseases of the eye, giving its layers and their uses. Hirshberg has praised his depth of experience in this field.

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[3] Kitab Al-Mansuri- French translation by de Koning, Bodleian Library, Oxford, Marsh collection

[4] Hamarneh, Arabic ophthalmology in 'Essays on Science 'by H.M. Said, Hamdard, Karachi 1987 pp 75-89

**Ali ibn Abbas al-Majusi** (994) composed a book on ophthalmology *Kamil al-San'aa al-Tibbiya.* It's translation in Latin by Constantine the African in the $11^{th}$ century was known as *Liber Regius* (*Kitab al-Malaki*). In the $13^{th}$ chapter there is description of eyes and its uses, eye ailments and their treatments like ophthalmia, swelling, hardness in conjunctiva, itch, pannus, blood spot, ulcers, pustules, protuberance in the eyes, treatment of corneal cancer, chemosis, thrush, tinea and scrofula. [5]

It was translated into Urdu by Hakim Ghulam Hussain Kantori and published from Lucknow in 1889. In this book he presented the idea of capillary system and Pterygium. He knew three eye ailments i.e. optic nerve, retina, and choroidal disease. He prescribed special foods for people

al-Majusi's ***Complete Book of the Medical Art*** in which it is stated that the copy was finished on 7 Dhu al-Qa'dah 604 [= 15 May 1208) http://www.nlm.nih.gov/hmd/arabic/E5_E6.html#E6

with eye ailments. He stated that people who have diabetes and kidney complications their eyes can be affected. He described 130 eye diseases, 143 simple drugs, and names of herbs beneficial for the afflicted eyes. It was translated into Latin 1499, French 1903, & in German 1904.

**Abul Qasim al-Zahrawi** (1009) was pioneer of modern surgery. He performed cataract operations and expounded it in detail. In his comprehensive book on surgery *Kitab al-Tasrif*, he divides eye diseases into 12 divisions, including those of the eyelids such as scabies, adhesion, and cohesion. He says chemosis is of two kinds. He described diseases of conjectiva such as ophthalmia, blood clot in the white of the eye, diseases of cornea such as ulcers, causing severe pain, headache and flowing of tears. In Maqala 30 he described surgical operations on the eye. He was the first one to give diagrams of surgical instruments. [6]

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[5] Y.Z. al-Hasan, Science & Technology is Islam, UNESCO, page 466, NY 2001

[6] M.S. Spink, On surgery and instruments ; a definitive edition of the Arabic text with English translation and commentary (Kitab al-Tasrif) , Welcome Institute, London 1973

**This page from a 14th century copy of Kitab al-Qanoon describes several internal organs, as well as skull and bones. National Museum Damascus**

**Ali ibn Isa** (Jesu Hali 1010) was a famous physician and eminent eye specialist of Baghdad. He produced his researches on ophthalmology in a book *Tazkira al-Kahhalain (Memorandum to Oculists)* which is a comprehensive tome on this topic in Arabic, combining Greco-Roman knowledge with his own observations. It is relates over 130 eye conditions. During the middle ages it was used as a text book in European medical colleges and considered a bible on the subject up to the 18th century. It consists of 3 volumes: volume 1 is on anatomy & physiology of the eye, volume 2 is external diseases of the eye, their causes and symptoms, volume 3 is hidden diseases of the eye that are not visible which cause damage to the eyes[7]. It was translated into Latin. Later it was printed by Daira'tul'ma'arif Usmaniyya, Hyderabad, India. Hirschberg wrote a commentary on it. 5

**Ammar bin Ali al-Mosuli** (1010 Cairo) was a distinguished royal physician of Fatimid Khalifa al-Hakim (996-1020). He was an expert eye specialist. His monumental work *Kitab al-Muntakhib fee Elaj al-Ayn (selected material on the treatment of the eye cures)* was dedicated to great patron of scholars Qazi Malak bin Sa'eed (1014). He gave detailed cures for eye ailments in a logical way. He dealt at length with anatomy of the eye, its physiology, and preparation of prescriptions. He explained 48 eye ailments, narrated some clinical cases, recorded his personal observations, and told about surgical instruments. He performed the earliest extraction of cataracts using suction. It was not until the 18th century that the removal of cataract by a hollow needle was employed in Europe. He described six types of cataract operations. George Sarton has described al-Mosuli as the pre-eminent eye doctor among all the Muslim ophthalmologists[8]. He invented his own method of operation for soft cataract by seduction through a

[7] . It has been translated into English; this writer has studied it at Queen's University Douglas Library Kingston, Ontario. Memorandum book of a tenth-century oculist for the use of modern ophthalmologists; a translation of the Tadhkirat of Ali ibn Isa of Baghdad (cir. 940-1010 A.D.), the most complete practical and original of all the early textbooks on the eye and its disease
'Ali ibn 'Isa, al-Kahhal, 10th century 1936 call number RE 41.A39

[8] George Sarton, History of Science, volume 1, 1927, page 729

hollowed tube. On his invention he wrote: "*Then I constructed the hollow needle, but I did not operate with it on anybody at all, before I came to Tiberias. There came a man for an operation who told me: Do as you like with me, only I cannot lie on my back. Then I operated on him with the hollow needle and extracted the cataract; and he saw immediately and did not need to lie, but slept as he liked. Only I bandaged his eye for seven days. With this needle nobody preceded me. I have done many operations with it in Egypt."*

Abu 'Ali al-Husayn ibn 'Abd Allah **ibn Sina** (1037) wrote The Canon of Medicine which first appeared in Europe at the end of the 12th century, and its impact was dramatic. Copied and recopied, it quickly became the standard European medical text book. In the last 30 years of the 15th century, just before the printing, it was issued in 16 editions; in the following century twenty further editions were printed. From the 12th to the 17th century, its *materia medica* was the pharmacopoeia of Europe. As late as 1537 *The Canon* was still a required textbook at the University of Vienna. He was the first one to describe six extrinsic muscles of the eye which control eye movements. He also expounded the dilation and contraction of the pupils and their diagnostic value, and discussed the functions of the tear ducts.

بسم الله الرحمن الرحيم
وبعد حمد الله والثناء عليه والصلوة على رسوله محمد وآله فان
هذه الكتب التي صنعناها في الطب التي الاول منها هو في الاحكام
الكلية من الطب والثاني منها هو هذا الكتاب المجموع في الادوية
المفردة وقسمنا هذا الكتاب مقالتين الاول منهما في
القوانين الطبيعية التي يجب ان يعرف من امر الطب في قوى الادوية
الجزوية اما الاول فقسمناها الى ستة فصول ا في تعرف الامزجة
الادوية المفردة ب في تعريف امزجة الادوية المفردة بالتجربة
ج في تعريف امزجة الادوية المفردة بالقياس د في تعريف
افعال قوى الادوية المفردة ه في احكام تعرض للادوية
في خارج و في التقاط الادوية وادخارها واما الثانية
فان جعلت الادوية المفردة فيها الواحا ا الاسماء الادوية
المفردة وتعريف ماهياتها ب لاختيار الجيد منها ج لذكر
كيفياتها وطبايعها د لخواص افعالها واحوالها الكلية

al-Qanoon 1030

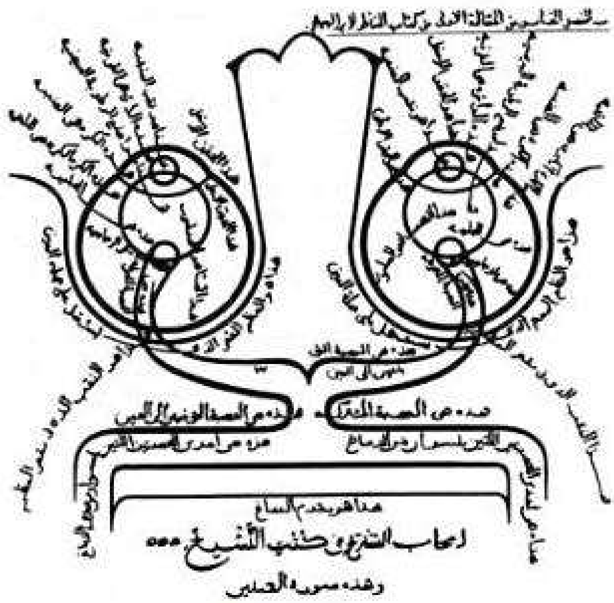
Ibn Sina is still a hero in the Muslim World. His portrait decks a wall in Bukhara Uzbekistan.

In *Kitab al-Qanoon* he described sight as one of the five external senses. [9]

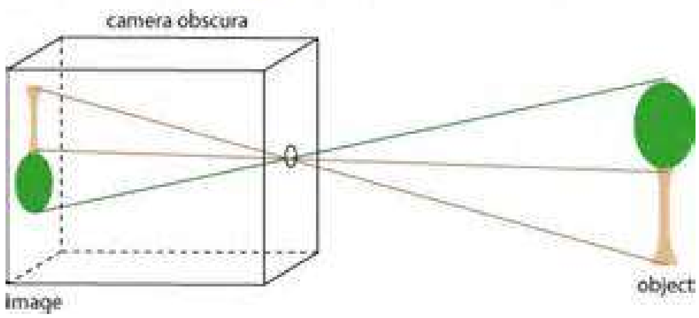
**Ibn al-Haytham** (1039 Cairo) the father of modern optics, provided anatomy of the eye in chapter five of his renowned & fundamental book on optics *Kitab al-Manazir*. He gave in the book physiology of the eye, specifically described cornea, humor aqueous, lens, and corpus vitreum. He examined the effect of light on seeing. He caused changes in the prevailing ideas of his age, and suggested that light came from objects, not from the eye. He provided information regarding the optic nerve, retina, iris, and conjunctiva. He showed the system of the eye as a dioptric, and the relations between the parts of the eye. It is understood that he mastered all knowledge on the structure of the eye in his century. The best proof of this is the eye picture that he drew. He devised technical terms to deal with sight, and everything concerned with it. For example Saqab al-anabiyya (Pupil), al-Qarnia (cornea), al-A'asab al-Basariyya (optic nerve), al-Bayzia (albugenous humour), al-Jalidiyya (crystalline humour), al-Zujajiyya (virtuous humour. He explained that vision was made possible due to refraction of light rays. After doing experiments he stated light falls on retina the way light falls in a dark room on the wall through a small hole. The inverted image made on the retina goes to brain through the optic nerve.

Ibn al-Haytham had used *a camera obscura* (bait al-muzlima) in his extensive optical experiments and compared it to the eye.

[9] Dr. M.H. Shah, English translation of Kitab al-Qanoon, Karachi 1966, NY 1970



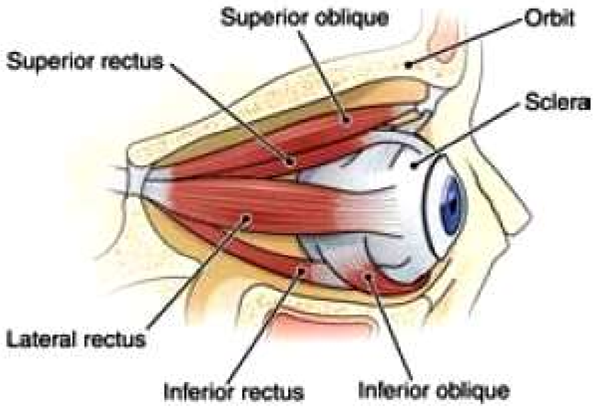
The eye, from Al-Hazen's *Opticae Thesaurus*—AD 1038.




Regarding perception, Prof. Charles Gross says: Ibn al-Haytham was the first to recognize the crucial importance of eye movement for perception. It is only in recent years that it has been recognized that there is indeed no perception without eye movements and that eye movements are crucial to building up our consciousness of the visual world Ibn al-Haytham realized that the reception of light by the eye is only the very first step in perception. Beyond this passive process, active processes such as comparison and memory are required before conscious visual experience occurs. *Tales in the History of Neuroscience* by Charles G. Gross (Bradford Book, 1999)

**Muhammad b. Ahmad al-Maqdisi al-Tamini** wrote *fee Mahiyat al-ramad wa-anwa-ihi wa- asbabihi wa Elajihi* (on Ophthalmia) in the last quarter of 10th century. He proposed that the retina was at least partially responsible for sight, explaining light falls on retina similar to light falling from a hole in the wall on a surface in the dark room. The image made on the retina is conveyed along the optic nerve to the brain. He used *camera obscura* to test his findings. He explained shape of the eye, sense of sight, what is light, nature of light, how do we see things, why man was given two eyes instead of one. He solved many optical problems by combining geometry with optics. He not only made lenses but amply used them in his discoveries. He used scientific method to disprove theories of his predecessors.

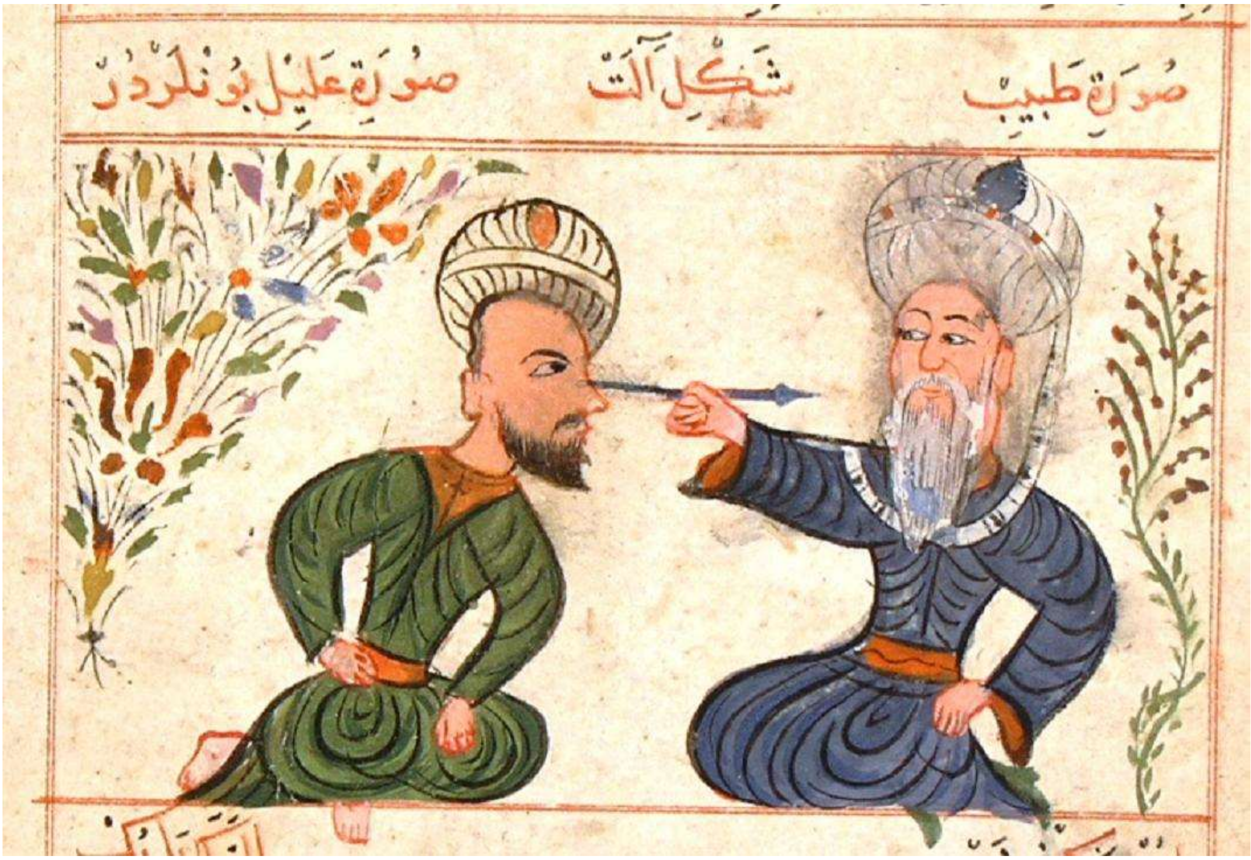
**Abu Muttarif** (11th century Spain) Prof. Hirschberg (1925) in his address to the American Medical Association California (1905) mentioned Abu Muttarif from Seville who flourished in the 11th century. Besides being an eye specialist he was also a Wazîr (minister). Unfortunately, his work is entirely lost.




**Muhammad ibn Mansur Zareendast** (1088 Iran) was a famous eye doctor during the reign of Saljuq sultan abul Fatah Malikshah (1093). He composed in Persian an encyclopedia on ophthalmology *Noor-al-Uyun* (light of the eyes). Hirschberg translated it into German in 1905 which was published from Leipzig. It consists of ten chapters. In the seventh chapter he describes some 30-eye operations including 3 types of cataract operation. He also deals with anatomy and physiology of the eye and eye diseases. One chapter is devoted to eye diseases which can be seen such as cataract, trachoma, scleral and corneal diseases and problems of the eyelids. Another chapter deals with diseases that lie hidden (the signs are exhibited in the eye and vision but the cause may be elsewhere) i.e. third nerve paralysis, blood disorders, toxicity etc. The book mentions curable and incurable diseases and gives methods of treatment. A large section is about surgery of the eye. There is a section on drugs employed by the oculists.[10]

**Samiuddin** explained headache caused by glaucoma which eventually causes blindness.

[10] http://www.muslimheritage.com/article/eye-specialists-islam




A painting depicting a Muslim physician during a treatment. Serefeddin Sabuncuoglu, *Cerrahat al-Haniyye*, Millet Library, Ali Emiri Tip, p. 79.

**Adnan al-Aynzarbi** (1153 Cairo) was an outstanding oculist of his time. He completed his studies and practiced medicine in Baghdad, subsequently immigrated to Cairo. He was court physician to the Fatimid ruler of Egypt, al-Zafir, (r.1149 - 1154) . In his *al-Kafi fi sina'at al-Tibb- What is Sufficient for the Medical Art* he explained scabies in the interior of the eyelid, its types, hardness of eyelids difficulty in closing and opening them, especially when waking up. He described chemosis occurring in the eyelid. He mentioned causes of expansion and contraction in the hole of the pupil, treatment of adhesion with hooks. Finally he explains conditions of snow whiteness, which happens due to intense whiteness such as looking at a snowy scene, or the weak eyesight so that the person only sees whiteness.

 Kitab al-Kafi fee Sina’at al-Tibb, A synoptic table displaying information for the treatment of the eye disease called *jarab* (trachoma).

**Qazi Nafis al-Din ibn Zubair** (12th century) was eminent physician, surgeon and eye doctor of India. Of the many physicians who worked at Bimaristan Hospital of Cairo, he was one of them. Muslim Kings Muhammad bin Tughlaq and Feroz Shah were interested in medicine. Feroz Shah authored a book *Tibbey Feroz-shahi* which gave descriptions of diseases not mentioned in *Kitab al-Qanoon*. Feroz was interested in surgery of the eye and eye disorders. He prepared a powder for eye cures *Kahal Ferozshahi* made of snake-skin and some native herbs.

Abu Jafar Ahmad bin Muhammad **al-Ghafiqi** (1165 Cordoba) composed *al-Murshid fil Kuhl* (Guide to Ophthalmology) in which he produced diagrams of instruments. It was partially edited with commentary by Max Meyerhof and printed in Barcelona in 1933. **Sa’ad bin Mansur** Israeli converted to Islam. His book *al-Kafee fil-Kabir* is a useful book on eye ailments.

 The bust of al-Ghafiqi is in quadrangle of a municipal hospital in Cordoba, Spain. It was erected in 1965 to commemorate the 800th anniversary of his death.

**Ibn Rushd** (1198 Spain) gave detailed account of eyes in his celebrated book *Kulliyat fil al-Tibb* (Principles of Medicine) chapters 2:15 and 3:38. After thoughtful studies he concluded retina and not the lens was the photo-receptor in the eye. [11] He was also the first to suggest that the principle organ of sight might be the

[11] For further research on this topic following article is recommended: Averroes view on the retina- Journal of the History of Medicine # 24, 1969, available in Douglas library, Queens University, Kingston.

arachnoid membrane (aranea). His work led to much discussion in 16th century Europe over whether the principle organ of sight is the traditional Galenic crystalline humour or the Averroist aranea, which in turn led to the discovery that the retina is the principle organ of sight.

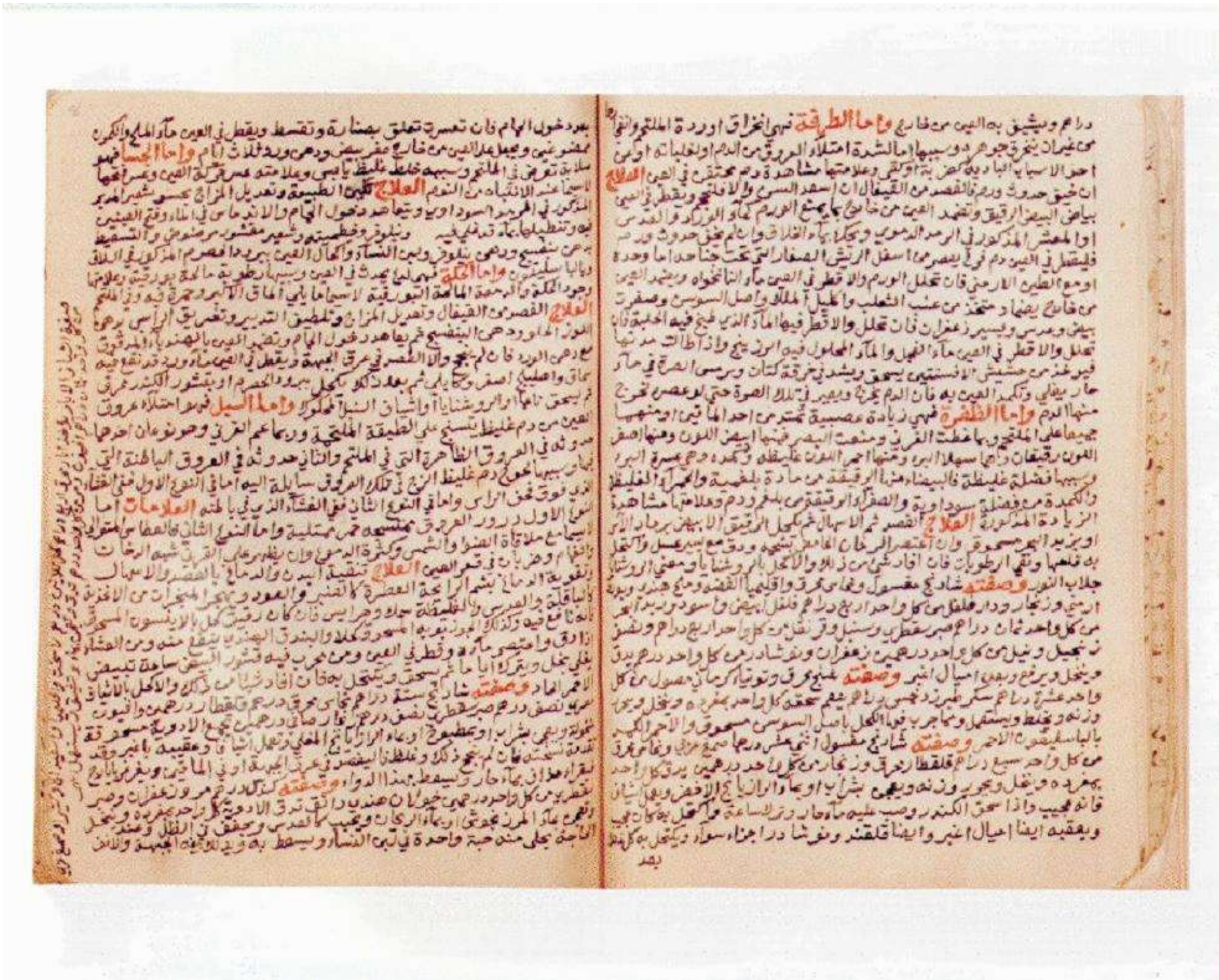
**Fath al-Din al-Qaysi al-Maqdisi (**1251Cairo**)** was a distinguished practitioner both in theory and practice. He was knowledgeable about causes and treatments of eye diseases & medications. His father was royal physician of Sultan al-Kamil. His title was *Rasees al-Ittib'a fee dayar al-Misr*


Ophthalmological manual of al-Qaysi, 1501

His book *Kitab Natija al-Fikr fee amaradh al-Basar* (The result of thinking about cure of eye disease) was produced at the request of al-Malik al-Salih Najm al-Din Ayyub (1249). It consists of 17 chapters: definition of the eye, uses, anatomy, how sight occurs, the temperaments and colors, diseases of conjunctiva, layer and the cornea, the iris, the humours, the retina, the choroids, disease symptoms and treatments, the hollow nerve, diseases of the muscles of the eyeball, eyelids, and canthus, weak eyesight, health of the eye, uvea, 124 eye conditions, lens, virtuous body, lacrimal glands , choroid, sclerotic, optic nerve and eye management. The book contains author's observations and unique experiences. Fourteen copies are known to be preserved today. German translation was produced by Hans-Dieter Bischoff, Frankfurt in 1988.

A copy of his masterpiece *Natija fikr fee Elaj amraz al-Basr* dated 16th November 1501, is in National Library of Medicine, Maryland.

**Khalifa abi al- Mahasan** (1256 Aleppo, Syria) was an eminent eye doctor of Syria. His 564 page tome *al-Kafi fil Kuhal* (fee khila'at) contains diagrams of 36 instruments, giving their names & its uses. He gave diagram of brain and its membrane, optic nerve, and the eye. He observed right eye controls the left side and left eye controls the right side. He discussed the visual pathways between the eye and the brain and also writes about twelve kinds of cataract operations (Arabic Nazul al-Ma'a al-ayn – water descending in eyes, making the lenses cloudy). He was so



AL-MAQDISI BOOK ***The Result of Thinking about the Cure of Eye Diseases (Natijat al-fikar fi `ilaj amrad al-basar)* written in Cairo by Fath al-Din al-Qaysi (d. 1259/657 H). Copy finished by unnamed scribe on 16 November 1501 (5 Jumada I 907 H). © The National Library of Medicine, Bethesda, Maryland, MS A48, fols. 7b-8a**

confident of his superior surgical expertise that he performed cataract operation on a person who had only one eye.

**Naseer al-Din al-Tusi** (1274 Iran) authored two treatises on optics i.e. *al-Mubahith fee anakas al-Isha'at wa inaytaf, & Tahrir al-Manazir.*

**Ibn al-Quff al-Karki** (1286) wrote *al-Umda fee Sinaa al-jirah*a (on the art of surgery) whose maqala 2 division 15 and maqala 3 division 3 are on the anatomy of the eyes. Other than this it contains nothing new in addition to writings of previous oculists like Zahrawi, Aynzarbi and others. *Al-Umda* was published by Dair'at al-Ma'arif Hyderabad in 1937.

**Alauddin ibn Nafis** (1289 Cairo) wrote a book *Kitab al-Mukhtar fil al-Aghziyya,* explaining effects of diet on health, which foodstuffs affect negatively. He discovered that the muscle behind the eyeball does not support the ophthalmic nerve, that they do not get in contact with it and that the optic nerve transact but do not get in touch with each other. He also discovered many new treatments for glaucoma and the weakness of vision in one eye when the other eye is affected by disease. His book *Kitab al-Muhazzab fil Kuhl al-Mujarrab -The Polished Book on Experimental Ophthalmology* is in two sections: On the Theory of Ophthalmology and Simple and Compound Ophthalmic Drugs. He denied that eyeball had three humours and seven layers. He observed retina has one layer, the same for choroid and the iris.

A commentary on the *Mujiz* al-Qanoon or *Concise Book* of al-Qanoon fil Tibb, called *The Key to the Mujiz* and composed in Arabic by al-Aqsara'i, who died in 1370 . October of 1407 © The National Library of Medicine, Bethesda, Maryland, MS A67, fol. 167b showing a schematic diagram of the visual system.

**Salah al-Din ibn Yusuf al-Kahal** (1296 Hims, Syria) composed a splendid book for his son *Noor al-Ayun wa Jamay al-Funoon* giving biographies of all the eye doctors up to his time. It is divided into 10 chapters: description of the eye as well anatomy and diagrams, theory of vision, eye disorders causes and cures, cleaning of eyes benefits of eye lashes, affections of canthi, affections of conjunctiva, affections of cornea, affection uvea & cataract, intangible affections, simple drugs for eye disorders. He gave many extracts from Ammar's treatise.

**Qutub al-Din Sherazi** (1311, Iran) was appointed eye doctor at Shiraz hospital where he stayed for 12 years. He wrote a book on eye ailments and cures. [12]He wrote on the following topics: Retina, optic nerve, chiasma, theory of vision.

**Sadaqa Ibn Ibrahim Shadhili** (14th century) wrote *Kitab al-Umda al-kahliyya fee amaraz al-Basariyya* which was a textbook in medical colleges of Egypt. It contains some interesting evidence as to the level and frequency of ocular surgery in his day. The treatise, consisted of five sections (*jumlahs*), each divided into subsections (*fasls*). He stated there is a strong connection between human brain and eyes. He observed color of eyes is different in each generation. He described four stages of trachoma; (**Egyptian ophthalmia)** infection causing a roughening of the inner surface of the eyelids.


Shadhili's Kitab al-Umda, there are 4 copies in the world, one in National Library of Medicine, USA. http://www.nlm.nih.gov/hmd/arabic/mon7.html#a29.1

**Daud ibn Umar al-Antaki** (1599 Antioch) was blind at birth, but nonetheless he learned Greek, in addition to Arabic. He wrote *Tadhkirat uli-l-Albab wal Jami lil ajab al-ajab* (Notebook for the intelligent, on the greatest marvels) contains an explanation of the eye diseases and their treatments. Although he was afflicted with blindness but endowed with wisdom and perception. Book is still available in bookstalls of Egypt.

**Ibrahim Ali ibn Talib** (17th Century) **ابراهيم ابن ابى طالب ابن على الحنفى Composed** *Istibṣār fī 'ilāj amrāḍ al-abṣār* – reflections on the treatment of ocular disease- an ophthalmological manual sometime before 1698. The treatise is divided into four chapters (*fanns*): the first on the anatomy and function of the eye, the second on external and visible diseases of the eye, the third on hidden diseases of the eye; and the final one on compound ocular remedies. Manuscript is in National Library of Medicine, Washington DC.

**Abdul Qadir al-Khulasi al-Damashqi** (18th Century) composed Kitab *Khulasa al-Tashrih* (epitome of surgery) explaining the function of each body organ, including the eye and its treatments.

A medical school was established in Abu Zabal (Egypt) in 1827, later moved to Qasr al-Ayni Cairo in 1835. One of the many outstanding scholars here was **Ahmad Hasan al-Rashidi** who authored *Kitab Dhiya al-nayirrin fee elaj al-aynayn* (On treatment of eye diseases) printed in Cairo in 1840. Oculists (كحال) were trained in Egypt in Qasr al-ayni and the hospital. [13]

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[12] C. Elgood, Medicine in Persia, page 66, 1934
[13] A.Y. al-Hassan, Science and Technology in Islam, volume 2, UNESCO, page 490, 2001

**Dr. Abdul Moiz Shams** (21st century, India) is a famous eye surgeon who practices in Dodhpur, Aligarh. He is the author of a book in Urdu Hamari Aankein (Our Eyes)[14]. His other books are: JISM o JAN, AANKHEIN AUR URDU SHAYERI is part of his Ph.D thesis, Medical Practice in Islamic Perspective. After receiving his medical degree from Ranchi Medical College, he received M.S. degree from Aligarh Muslim University. He has earned degrees from Austria and USA also. In addition he has received training and education in ophthalmology from Japan, Singapore and Malaysia. He has worked as an eye surgeon in various hospitals of India, Iran and Arabia. He has travelled to many countries of Asia and Africa in order to perform eye operations on less fortunate people. In India he conducts a free eye camp in backward areas of the country to perform eye operation. He is member of world renowned program Prevention of Blindness. All in all in 40 years he has performed 15,000 free eye operations and treated 70,000 patients. The author of this article had the honor and privilege of meeting him during my visit to Aligarh in November 2013. (moizshams@yahoo.com)
http://www.aligarhadda.com/business/details/modern-eye-care-centre-aligarh

Conclusion

The Muslim oculists used many sophisticated treatments for external injuries to the eye, many of which are completely recognizable to modern oculists. For example, styes were seen as an abscess and were treated by rubbing with hot bread; modern hot compresses do exactly the same job. Trichiasis, where ingrowing eyelashes scratch and damage the surface of the cornea, leading to gradual blindness, was treated by removal of the hair and the cauterization of the root with a red-hot needle.

Islamic ophthalmology increased the body of knowledge available and saved the sight of countless thousands of patients suffering from afflictions of the eye. Their contribution to ophthalmology as well as to Islamic medicine was immense and reinforces the work of modern practitioners in the field.

In 250 years, Muslims eye specialists produced eighteen written works on ophthalmology. Whilst the Greek tradition, from Hippocrates to Paulus, spanning one thousand years, produced only five books on this subject. In all, there are some thirty ophthalmology textbooks produced by the Muslim scholars, twenty-eight are listed below.

List of Books Compiled by Muslim Authors on Ophthalmology
or chapters devoted in their books

| | Author | Name of the Book in Arabic |
|---|---|---|
| 1. | Hunayn ibn Ishaq | Kitab al-Ashr maqalat fil al-ayn |
| 2. | Zakariya al-Razi | Kitab al-Havi, al-Mansuri |
| 3. | Abul Hasan al-Tabari | Mua'alijat al-Buqratiyya |
| 4. | Ali ibn Abbas al-Majusi | Kamel al-Sina'at fil al-Tibbiya |
| 5. | Al-Zahrawi | Kitab al-Tasrif\ |
| 6. | Ali ibn Isa | Tadhkara al-Kahalain |
| 7. | Ammar al-Mosuli | Kitab al-Muntakhab fee Elaj al-Aayn |
| 8. | Ibn Sena | Kitab al-Qanoon |
| 9. | Ibn al-Haytham | Kitab al-Manazir (optics) |
| 10. | Al-Tamimi | Mahiya Ramadh wa anwa-e-ha |
| 11. | Zareendast | Noor al-Ayun |
| 12. | Adnan al-Aynzarbi | unknown |
| 13. | Ibn Zubair | unknown |
| 14. | Al-Ghafiqi | al-Murshid feel al-Kahal |
| 15. | Sa'ad ibn Mansoor | al-Kafi feel Kabir |

[14] Dr. Moiz Shams, Our Eyes, Islamic Foundation for Science, Zakir Nagar, Dehli 110025, 2004

16. Ibn Rushd Kulliyat feel al-Tibb
17. Al-Maqdisi Natija al-fikr fee amradh al-Basr
18. Khalifa abi al-Mahasan al-Kafee fil –Kahal
19. Fath al-Din Qaysi Natija fee fikr elaj al-Amradh al-Basr
20. Naseer al-Din Tusi *Tahrir al-Manazir*
21. Ibn al-Quff *Umda fee San'at al-Jaraha*
22. Ibn Nafees *Kitab al-Muhazzab fee kul al-Mujarrab*
23. Salahuddin ibn Yusuf *Noor al-Ayoon*
24. Qutab al-Din Sherazi unknown
25. Ibrahim ibn Ali Talib *Istibṣār fī 'ilāj amrāḍ al-abṣār*
26. Al-Damishqi Kitab khulasa al-Tashreeh
27. Ahmad Hasan al-Rashidi Kitab Dhiya al-Nayrain fee elaj al-aynain
28. Dr. Moiz Shams Urdu – Hamaree Aa'nkhein (our eyes)

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Our eyes are incredibly a remarkable piece of equipment allowing us to take in the wonders around us. It does what most TV cameras do, it does instant focusing, and it's got full three color vision. They may seem like simple orbs in the head, in fact they are a complex organ of the human body. Eyes have astonishing attributes, and they can also do number of amazing things. They are the second most powerful organ in the body using 65 percent of the brainpower.

To end this article on a upbeat note, I would like to give idioms and phrases in English language with respect to eye: apple of someone's eye, bird's eye-view, catch someone's eye, Eagle eye, cry one's eyes out, feast one's eye on something, get a black eye, give someone the eye, get stars in one's eyes, have eyes bigger than your stomach, have eyes in the back of someone's head, in the public eye, hit the bull's eye, keep one's eye on the ball, turn a blind eye to something, without batting an eye, eye catching, eye pleasing, in the eye of the storm, beauty in the eye of the beholder, can't take eye off, an eye for an eye, do something with eyes closed, in the eye of the storm, eye in the sky, eye-opener, more than meets the eye, to have an eye for something, feast one's eyes on, in mind's eye, ogling, feast one's eyes on, delight of one's eyes. *Arabic Noor al-Ayni*, light of my eyes, see eye to eye with.

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Chapter 2

# Muslim Contribution to Pharmacy

This article will focus on Medieval Muslim scholars – physicians, botanists, chemists, and translators who contributed profusely in the development of pharmaceutical knowledge and the art of drug making.

Interest in the development of pharmacy in Islamic lands was led by poisons, their antidotes and means of detecting the poisons. Therefore much of the groundwork for early pharmacy was laid down by toxicologists. Initially knowledge of medicinal substances was based upon the 600 plants or plant products described by Greek physician Dioscorides (90CE) for 1000 remedies in his treatise *De materia medica*. Arabic translations of this Greek book formed the basis for much of the future advances made by Muslims in pharmacology and pharmacy. Subsequently numerous Arabic and Persian treatises were written on medicaments. The knowledge Muslim pharmacists inherited from Syria, Persia, India and the Far East formed the basis for future innovations. Muslim pharmacists remained unsurpassed in this field until the 17th century.

Islamic pharmacy (*Saydanah*), the art of preparing and dispensing drugs, separate from the profession of medicine was recognized in the 8th century. Sandalwood was used in pharmaceutical preparations and it soon became associated with the profession. Pharmacies were called in Arabic *as-Saydanah* and pharmacists were called *as-saydanani* or as-saydalani. In India sandalwood was used more than any other aromatic woods. In Sanskrit sandalwood was called chandan or jandan. In Arabic a person who sells amber is called anbari, therefore the person who traded in sandalwood was called sandalani. The title of saydalani is given to a qualified pharmacist. Supposedly the first person to be given the title of al-Saydalani was the Baghdad resident, Abu Quraysh al-Saydalani. Islamic pharmacy involved herbalists, collectors and sellers of medicinal herbs and spices, manufacturers, sellers of syrups, cosmetics, aromatic waters, and pharmacist authors.

Drug stores were first established in Baghdad in 754, where drugs were prepared and sold. The drug stores and the work carried on in them, was inspected by *Mohtasibs* (inspectors). Market Inspectors were responsible for checking the cleanliness of the containers, preparation of drugs and their dispensing. During the reign of Caliph Mamun al-Rashid (d.833) licensing system was introduced. The druggists and the physicians had to pass an examination in order to obtain a license to practice. Licensed pharmacists were called *Sayadala*. **Sinan ibn Sabit** (d.943), director of Baghdad hospital, was the first administrator of licensing department and founder of public health system.

Islamic pharmacy introduced 2000 new substances including anise, cinnamon, cloves, senna, camphor, sandalwood, musk, myrrh, cassia, tamarind, nutmeg, cloves, aconite, ambergris, and mercury. They introduced hemp as an anaesthetic. They were first to develop syrups and juleps, new pills, elixirs, confections, tinctures, and inhalants. Muslim pharmacists made scientific investigations of the composition, dosages, uses, and therapeutic effects of drugs.

Pharmacy during Umayya Period

The first figure associated with the development of Islamic pharmacy was grandson of Caliph Hadhrat Muawiyyah, **Prince Khalid bin Yazid** (d.704). Khalid was more interested in alchemy than to be a future ruler. He asked alchemist of Alexandria Marianos to teach him alchemy. In order to trans-mutate metals into gold, he collected various herbs, did some experiments but gained nothing. Under his direction translations of Greek texts into Arabic were made for the first time in the Islamic world. Translators were given stipends, and soon several Egyptian and Greek books of medicine, chemistry and astrology were translated into Arabic. He was the first one to establish a library in the Islamic world.

During Abbasid Period

**Jabir ibn Hayyan** (d. 815 Kufa) was a renowned chemist and alchemist. He is considered to be the father of modern chemistry. In chemistry he emphasized systematic experimentation, and freed chemistry from superstition. He is credited with the invention of over 22 types of basic laboratory equipment, such as the alembic and retort. He invented many commonplace chemical substances – such as the hydrochloric acid, nitric acid and processes – such as sublimation, calcinations, crystallization, evaporation, dissolution.

**Ali Bin Sahl Rabban al-Tabari** (d.870) served as a government officer and physician under the rule of Caliph al-Mu'tasim (833-842). Al-Tabari wrote a famous book *Firdaus al-Hikma* (Paradise of Wisdom) which was completed in 850. In addition to discussing diseases and their remedies, he included several chapters on materia medica. He urged that therapeutic value of each drug be reconciled with the particular disease. For storing the drugs he recommended glass or ceramic vessels for liquid drugs, small jars for eye liquid salves, & lead containers for fatty substances

The first medical formulary (*Aqrabadhin*) was written in Arabic by **Sabur bin Sahl** (d.869). The book included recipes for compounding the drugs, remedies for ailments, their pharmacological actions, dosage and the methods of administrations. It was written as a guidebook for pharmacists. Medical encyclopaedias always had one chapter on *materia medica*, & another on recipes for compound remedies. Drugs were classified into simple (*mufradat*) and compound (*murakkabat*). Compound drugs were considered more likely to be effective, the more complicated and rare ingredients they contained, the more expensive they were likely to be.

Yakoob Ibn Ishaq **Al-Kindi** (d.873) made important contributions in medicine, pharmacy and optics. Of the 265 works he penned, more than 30 dealt with pure medicine. He developed a mathematical scale to determine in advance, based on the phases of the Moon the most critical days of an illness. He invented a branch of medicine called posology, which dealt with the dosages of the drugs. Dosages for the drugs were a guessing game in the ancient world. He created easy-to-use table that pharmacists could refer to when filling out prescriptions. By documenting amounts with a mathematical formula that anyone could follow, al-Kindi revolutionized medicine. Drugs could now be formulated according to set amounts with the result that all patients would receive standardized dosages. His book on posology, *Risala fe ma'rifat quwa al-adwiya al-murakkaba* was translated into Latin as *De*

*Medicinarum Compositarum Gradibus Investigandis Libellus* (The investigation of the strength of compound medicine). In his *Aqrabadain* (*Medical Formulary*), he describes many pharmaceutical preparations, including simple drugs virtually derived from natural botanical sources as well as animal and mineral sources.

Muhammad Ibn **Zakaria al-Razi** (d.925) introduced into pharmacy the use of mild purgatives, cupping for cases of apoplexy (sudden effusion of blood into an organ) and cold water for fevers. In Baghdad, he was made director of Muqtadari hospital, where he acted as a chemist to mix drugs for patients. He was the first to identify many diseases such as asthma, smallpox, chicken-pox and treated them successfully. He was the first physician who used alcohol as antiseptic. He invented many tools such as the mortar and pestle that are used by pharmacists. His books *Qarabadain Kabir* (The Great Book of Krabadain) , and *Qarabadain Saghir* (The Little Book of Krabadin) were important in pharmacology in that they introduced 829 novel drugs. He promoted the medical uses of chemical compounds. Razi was the first to write a book on home remedies, *Tibb al-Fuqara.* In its 36 chapters, he described diets and drugs that can be found in the kitchens, pharmacies, and military camps. Books on this theme continued to appear until the 20th century. In his famous *Kitab al-Mansuri* he devoted 4 chapters to diets and drugs, toxicology, antidotes, & compound remedies. In his collection of *Mujarrabat*, i.e. medicine tested in actual cases, Razi described 650 cases of men, women and children. Thus the number of 650 can be extrapolated into a rather large medical practice. A manuscript of *Kitab al-Tajarib* is preserved at Topkapisarayi, Ahmad III, 1975, Istanbul.

**Muhammad ibn Ahmad al-Maqdassi** performed pharmaceutical experiments and wrote several books as guides to materia medica**. Abu al-Qasim al-Zahrawi** (936-1013) pioneered the preparation of drugs by sublimation and distillation. His *Kitab al-Tasrif* (Latin: *Liber servitoris)* provides the reader with recipes and explains how to prepare the `simples' from which were compounded the complex drugs then generally used.

**Prince of Physicians Ibn Sena** (d.1048) wrote a book *Adwiya al-Qalbiyya* (Cardiac Drugs) which contains 760 drugs. He prepared medications for many kings and Sultans of his time. He devoted a whole volume to simple drugs in his masterpiece *Kitab al-Qanoon fil Tibb*. His most enduring work in pharmacy was laying down the following rules for testing the effectiveness of a new drug or medication. 1. The drug must be free from any extreneous accidental quality. (2) It must be used on a simple, not composite disease. (3) The drug must be tested with two contrary types of disease, because sometimes a drug cures one disease by its essential qualities and another by its accidental ones. (4) The quality of the drug must correspond to the strength of the disease. For example, there are some drugs whose heat is less than the coldness of certain diseases, so that they would have no effect on them. (5) The time of action must be observed, so that essence and action are not confused. (6) the experimentation must be done with the human body, for testing a drug on a lion or a horse might not prove anything about its effect on man.

Ibn Sena's contemporary, **Al-Biruni** (973-1050) wrote one of the most valuable Islamic works on pharmacology entitled *Kitab al-Saydalah fee al-Tibb* (*The Book of Drugs*), where he gave detailed knowledge of the properties of drugs and outlined the role of pharmacy and the functions and duties of a pharmacist. The first part of the book contains authentic definitions of the apothecary art as well as pharmacology, therapeutics and related fields of the healing arts, lexicology and lexicography, toxicology, omissions and substitutions of drugs, and their synonyms. The second part is devoted to materia medica in which Biruni explains over 700 simple drugs of the three natural kingdoms scrupulously arranged in alphabetical order. Quite a few of these simples were never mentioned before by the Greco-Roman authors prior to the Arabian period. Many of these, Al Biruni must have observed during his 13 travels in the Indian subcontinent. A pharmacist, he said, is a professional who collects the best and the finest of the simples and drugs and uses the best of methods for preparing his compounds."

He promoted the academic training of pharmacy students together with day to day practical experience with drugs. He expected these trainees to become familiar with the shapes, physical properties, and numerous kinds of drugs. Thus they would be able to differentiate one from the other. He argued that a pharmacist should be able to substitute one drug for another. The knowledge of how drugs work (pharmacology) is more important than the skill of preparing them. When substituting one drug for another, reactions of each drug should be considered. Cure can be sought through a draft, ointment, anointing oils or by fumigation. In seeking a substitute, therefore all these and other applications should be kept in mind.

**Yahya ibn Jazla** (d.1100) composed *Taqwim al-Abdan fi Tadbir al-Insan*, which consisted of 44 tables. 352 diseases were arranged like the stars in the Zijes (astronomical tables), He was the first one to use tabular form of summary. Ibn Jazla also wrote another .work, *Al-Minhaj fi Al-Adwiah Al-Murakkabah*, (Methodology of Compound Drugs), which was translated by Jambolinus and was known in Latin translation as the *Cibis et medicines simplicibus*.

The first pharmacological book by a Muslim was compiled by **Abu Mansur Muwaffaq** who lived in Herat in the 10th century, present day Afghanistan. He was apparently the first to think of compiling a treatise on *materia medica* in Persian; he traveled extensively in Persia and India to gather the necessary information. Around 977 he wrote, the *Kitab al-abniyia 'an Haqa'iq al-adwiya*, (*The foundations of the true properties of Remedies* ) which is the oldest prose work in modern Persian. It deals with 585 remedies (of which 466 are derived from plants, 75 from minerals, 44 from animals), classified into four groups according to their action. The original manuscript of this book is preserved in a library in Vienna. Abu Mansur made a distinction between sodium carbonate and potassium carbonate, and seems to have had some knowledge about arsenious oxide, cupric oxide, silicic acid, and antimony. He knew the toxological effects of copper and lead compounds, the depilatory virtue of quicklime, the composition of plaster of Paris and its surgical use. He also describes the distillation of sea-water for drinking.

Ibn al-Quff was apparently the Arab physician to call for a standard set of weights and measures in medicine and pharmacy. He is also known to have excelled in anatomical descriptions of the body, especially of the heart and the blood system.

Pharmacy in Islamic Spain & Maghrib

**Saeed ibn Abd Rab**bihi (d.960) was a pharmacist-physician of Cordoba. His *Kitab al-Dukkan* (The Pharmacy Shop) consisted of 17 chapters on compound drugs and recipes. **Ahmad Ibn al-Jazzar** (d.984) practiced medicine in Qayrawan, Tunisia. In his apothecary shop in the city of Manastir he kept syrups, electuaries, and other reparations. His shop assistant Rashiq helped in dispensing the medications. He was well known in Islamic Spain during the rule of Caliph al-Hakam (961-976). By running a successful business he acquired much wealth and fame. His medical compendium *Za'ad al-Musafir* comprised of seven treatises, and divided into two parts. His book *Kitab al-I'timad* al-adwiya al-Mufrida was on the pharmacological effects of tried and useful simple drugs. It was translated into Latin, Hebrew and Greek and exerted a profound influence on medical education in Europe. However this book was refuted by Egyptian ibn al-Haitham in his book *Kitab al –Iqtisa'd wal Ijad fee Khata ibn al-Jazzar fil I'timaad".* His book *al-Bughiya* on compound drugs was written as a complimentary to *al-I'timad*. *Tibb al-Fuqara wal Masakin* was intended for poor people who could not afford a doctor and imported drugs. Anyone could cure common diseases by buying readily available herbs.

**Abul Qasim al-Zahrawi** (936-1013) was considered the greatest medieval surgeon and one of the fathers of modern surgery. In volume 27 of his 30 volume magnum opus *Kitab al-Tasreef*, he provided the readers with recipes for preparing *simples* from which were compounded the complex drugs then generally used. He pioneered the preparation of drugs by sublimation and distillation.

**Abu Salt Umaiyah Andalusi** (d. 1134) was a resourceful physician, astronomer, mathematician, and an eloquent poet. His brief compendium on materia medica al-*Adwiyah al-Mufradah* was in use in hospital pharmacies in Egypt. The *simples* were listed according to their therapeutic action on various body organs. The book was translated into Latin by Arnold of Villanova in second half of the 13th century. His works have received good attention especially from German speaking scholarship. **Abdul Malik Ibn Zuhr**( d.1161) wrote *Kitab al-Aghziya* describing various types of foods and drugs and their effects on a person's health. In his *Kitab al-Iqtisad* he gave a summary of diseases, therapeutics and hygiene, written especially for the benefit of the layman. His pharmacopoeia was the first Arabic book to be printed with a movable type in 1491. He developed drug therapy and medicinal drugs for the treatment of specific diseases.

**Qazi Ibn Rushd** (1126-1198) completed in 1162 his seven volume medical encyclopedia *Kitab al-Kulliyat fil Tibb* in which he devoted two volumes to materia medica and general therapeutics.

**Ibn Baytar** (d.1248) described some 1400 drugs derived from various plants including some 200 new plants in his book "*Kitab al-Jamey fil Adwiya al-Mufrada*". It was based on 300 actual plants discovered by him along the length of Mediterranean coast between Syria and Spain. This was one of the greatest botanical compilations dealing with medicinal plants in Arabic. The book refers to works of some 150 previous Arabic authors, and also quotes 20 Greek scientists. According to Max Meyerhof, "it is a work of extraordinary erudition and observation". All the drugs were listed in alphabetical order. The book surpassed that of Dioscorides and remained in use until the 19th century. His second book on the subject *Kitab al-Mughni fil Adwiya al-Mufrada* was published around 1260 where drugs were listed therapeutically. It consists of 20 chapters, dealing with ailments of the head, eye, ear, and general antidotes. Ibn al-Baytar discovered the earliest known herbal treatment for cancer: *Hindiba*, a herbal drug which he identified as having anticancer properties and which could also treat other tumors and neo-plastic disorders. After recognizing its usefulness in treating neo-plastic disorders, Hindiba was patented in 1997 by Nil Sari, Hanzade Dogan, and John K. Snyder

Andulasian physician **Abu Ja'afar al-Ghafiqi** (13th century) was a pioneer in medical botany, pharmacy and materia medica. In his encyclopedic text On Simples, he gave more than 350 colored renderings of plants and animals arranged alphabetically. **Haji Zain al-Attar** (1329) wrote a small treatise *Miftah al-Khazain* in 1366 which contained pharmacological information in three parts. The first part is on simple drugs, second on their rectification and the third on compound drugs.

A book on pharmaceutical formulae, *Aqrabadain Kabir* was written by **Sabur ibn Sahl,** was so good that it was imitated by many during the Middle Ages. The original in Arabic was lost, but the Latin translation was used as a model for future Pharmacopeias.

**Ishaq ibn Imran** was an Iraqi physician who moved to Tunisia to serve the prince of Aghlabid dynasty, Ziyadatu –Allah. He was famous for his discourses on melancholy, a treatise on pulse and one on materia medica. **Ibn Sulayman al-Israili** was his eloquent student who served the Prince after his master's death. The manuscripts for Ishaq's book on diet and drug therapy entitled, *Aqwil fee Taba'i al-Aghziyya wal 'adwiya* are preserved in libraries of Istanbul, Madrid, Munich and Paris.

**Said al-Tamimi** was born in Jerusalem. His grandfather taught him all aspects of theory and practice of medicine. A Coptic monk Zakariyya bin Sawwab honed his skills in the use of therapeutics and the preparation and compounding of drugs. He also excelled in preparing the great theriac and composed a book on the topic entitled *Fee Sana't Tiryaq al-Farooq wa Na't Ashjarih.* He described therapeutic properties of plants mentioning the time of harvest, methods of collecting, compounding and final theriac preparation. His *al-Murshid* was excellent source for descriptions of natural products and their uses. Part 1 of the book was devoted to aromatic medicinal plants, flowers, wines, and waters as well as a formulary for preparing syrups, elixirs and ointments. Discussing the theraupetic uses of Dead Sea waters, he says "its waters cur many diseases of man and beast.

Pharmacy in India

Sultan Alauddin Khilji (1296-1316) had several eminent Hakims in his royal courts. This royal patronage was a major factor in the development of Unani practice in India, but also of Greco-Islamic (Unani) medical literature with the aid of Indian Ayur-vedic physicians.

During the reign of Moghul kings of India several Qarabadains were compiled like Qarabadain Shifae'ee, Qarabadain Zakai, Qarabadain Qadri and Elaj-ul-Amraz. In these pharmacopoeias quantities of drugs in a given prescription were specified, and methods of preparation. The court physicians supervised the preparations of royal medicine, which were sealed to ensure safety. Hakeem Ali Gilani was the chief physician of Emperor Akbar and used to accompany him in his travels. Hakim Gilani used to carry his pharmacy with him in these travels. He invented a kind of sweet wine for getting rid of traveling fatigue. During the reign of Emperor Jehangir, Itr-i-Jehangiri was discovered by Queen Noor Jehan. Hakim Ain-ul-Mulk Shirazi composed for his royal patron emperor Shah Jahan *Alfaz-al-Adwiyya* (vocabulary of drugs). It was printed in 1793 in Calcutta, and rendered into English by Gladwin. Hakim Akbar Arzani, was a court physician of Emperor Aurangzeb. He wrote *Tibbe Akbari*, and *Mizan al-Tibb*.

During the British rule, Eastern medicine in India declined. However the famous house of Hakim Sharif Khan of Dehli made a concerted effort to rejuvenate the decaying art of Unani medicine. Hakim Ajmal Khan founded the Hindustani Dawakhana and the Tibbiya College in Dehli. At the Tibbiya College, Dr Salimu-Zaman Siddiqui carried on chemical investigation of certain potent drugs and *Ajmailain* was produced. At Lucknow, the Talim al-Tibb college was established under the auspices of Hakim Abdul Aziz.

Hakim Kabir al-Din was a distinguished author who wrote four books on Eastern system of medicine: Masaela Dauran-ey-Khoon, Sharah Qanoon Shaikh, Tashrih Kabir, Ilm al-Adwiyya and Burhan.

Muhammad Husayn al-Aqili al-Alavi, a practitioner and grandson of a well-known Indian practitioner wrote in 1732 ***Makhzan al-adwiyah dar-i bayan-i adwiya. The*** illuminated Persian manuscript, now at the National Library of Medicine, USA is in alphabetical order.

At Lahore Hakim Ghulam Nabi and Hakim Ghulam Jeelani promoted Eastern medicine by writing books such as: *Tarikh al-Ittiba*, and *Makhzan al-Adwiyya*. After the demise of Hakim Ajmal Khan, Hakim abdul Majid (d.1922) started a pharmacy in 1906 which blossomed into Hamdard Waqf Laboratories. Hamdard now is a leading pharmaceutical house in India and Pakistan.

Hakim Syed Zillur Rahman (b.1940**)** is well known for his contribution to Unani Medicine in India. He founded in Aligarh Ibn Sina Academy of Medieval Medicine and Sciences in 2000. He has served as Professor and Chairman, Department of Ilmul Advia (Pharmacology) at the Ajmal Khan Tibbiya College, Aligarh Muslim University, Aligarh, for over 40 years before retiring as Dean Faculty of Unani Medicine. He has authored 45 books and several papers on different aspects of Greco-Islamic medicine. The library named in his honor holds one of the most precious and valuable collection of 20,000 printed books, 500 manuscripts, some rare books, microfilms, compact discs.

## Pharmacy in Pakistan

The Unani medical system is still flourishing in Iran and the Indian sub-continent, it is especially strong in Pakistan. The Unani system is sometimes called Hikmat or Unani-Tibb. Its medical practitioners are called Hakims. In Karachi Hamdard is a household name and employs thousands of doctors, scientists, pharmacists, and chemists. The Society for the Promotion of Eastern Medicine has compiled a comprehensive pharmacopeia of Eastern medicine in Urdu and English. It sets out standard procedures for the preparation of drugs, powders, calcinated medicine i.e. Kushtas, syrups and sherbets.

Under the leadership of Hakim Mohammed Said (d.1998), Hamdard Dawakhana expanded its mission; in addition to becoming a mega Foundation, it established an academy that became a major University (which includes a department of Eastern Medicine as well as other medical sciences), and a trust to house scholars and students. The pharmaceuticals branches in Delhi and Karachi have become the world's largest producers of Unani products. There are nearly 30 other major herbal companies in Pakistan that follow Hamdard's lead. It has published 300 medical books.

| **Botanical Name** | **Common Name** |
|---|---|
| *Terminalia species* | Beleric myrobalans |
| *Emblica spp.* | Myrobalans |
| *Ptychotis ajowan* | Ajowan |
| *Cassia angustifolia* | Senna |
| *Foeniculum vulgare* | Fennel |
| *Cinnamomum zeylanicum* | Cinnamon |
| *Sesamum indicum* | Sesame seed |
| *Piper nigrum* | Black pepper |
| *Coriandum sativum* | Coriander |
| *Glycyrrhiza glabra* | Licorice root |
| *Mentha spp*. | Peppermint |
| *Viola odorata* | Violet |
| *Rosa damascena* | Red rose |
| *Zingiber officinale* | |

Materia medica are books that deal with known curative substances, their origin, identification, & classifications as natural products from plant, animal and mineral.
How these substances are collected, prepared, and administered in the treatment of disease.

**References**:

Hakim Mohammad Said: Pharmacy and Medicine Thru the Ages, Karachi, 1980.
Hakim Mohammad Said: Medieval Muslim Thinkers, Dehli, 1991
http://www.ishim.net/ishimj/4/02.pdf - contributions of Razi in the history of Pharmacy.

http://www.cancerlynx.com/FRONTsection.PDF   Dioscorides MateriaMedica online
Hakim Mohammad Said: Greco-Arab concepts on Cardio-vascular disease, 1983 Karachi
Mahmoud Sadek, Arabic materia medica of Dioscorides, Quebec, 1983
Franz Rosenthal, Science and Medicine in Islam, Vermont, USA, 1990
Howard Turner, Science in Medieval Islam, Illustrated Introduction, Austin, USA, 1995
http://www.ibnsinaacademy.org/   Ibn Sena Academy, India
Tony Abboud, Al-Kindi- father of Arab philosophy, New York, 2006
S.K. Hamarneh, Health Sciences in Islam, Dec. 1984
Dr. A.Y. al-Hassan, Science & Technology in Islam, part II, UNESCO, Paris, 2001

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Chapter 3

# Muslim Contribution to Mathematics & Astronomy

Mathematics was introduced into Muslim culture through the Holy Quran where complex rules of inheritance are outlined.(1) Learning is greatly emphasized in the Holy Quran as well as in numerous sayings of the Prophet of Islam. For instance, Prophet Muhammad said that " *Tafakkaru saate khairu min ibadate sitteen sanat*" - one hour of pondering is better than sixty years of worship. It is also recorded that Prophet Muhammad would free prisoners of war on condition that they teach a Muslim reading and writing. Next to medicine, the Islamic civilization has produced the most conspicuous creative work in mathematics and astronomy. In this paper a brief history of translation during the Abbasid caliphate will be given, and then contributions made by 26 prominent Muslim astronomer/mathematicians will be provided.

The cultural awakening in Islamic world took place during the second half of eighth century (750) which undoubtedly saved the ancient sciences being lost for ever. By 766 we learn that an astronomy book *Surya Sidhanta* ( Sindhind) was brought to Baghdad from India. In 775 this book was translated into Arabic and not long afterward Claudius Ptolemy's *Tetrabiblos* was translated from the Greek. Baghdad being the seat of a world controlling power, the center of industry and commerce, the scene of boundless luxury and reckless indulgence, it became also an academy of learning. (2) Scholars belonging to all faiths were called from Syria, India, and Iran to take part in this intellectual activity.

**Translation work**

It was under three caliphs al-Mansur (754-775), al-Haroon (786-802), and al-Mamoon (813-833) translation work received under royal patronage. However ,it was during the caliphate of Abdullah al-Mamoon, that Muslim scholars fully indulged their passion for translation. The Caliph is said to have a dream in which Aristotle appeared and as a consequence he decided to have Arabic translations made of all Greek books including Ptolemy's Almagest and Euclid's Elements. From the Byzantine empire, the Caliph acquired Greek scientific and philosophical manuscripts through political treaties. It is related that one of the terms of peace which he forced on all whom he fought and conquered was unconditional surrender of all literary and scientific books. He went to considerable difficulty to obtain Greek manuscripts and obtained many holographs by paying a hefty price for these. He even sent a diplomatic mission to the Byzantine emperor Leon the Armenian (812-820) in this connection. It is said that a collections of rare books came from Cyprus also.

Al-Mamoon (786-833) established at Baghdad in 830 AD an academy of science 'Baitul Hikma' at a cost of 200,000 dinars. It consisted of a vast library with a regular staff, residence for students, a translation bureau, an observatory, core of translators and copyists. In this observatory scholars verified the length of solar year, precession of the equinoxes, the obliquity of the ecliptic and studied sunspots.

Al-Mamun built another observatory on the mount overlooking Damascus and thirty others followed soon after. The astronomers of Baghdad performed one of the most delicate geodisc operations when they measured the length of a terrestrial degree. The study yielded 56 2/3 miles as the length of a degree of a meridian, only half a mile more than our current calculation. Needless to say Muslim astronomers have left on the skies traces of their legacy in the names of  stars such as  Acrab (scorpion), algedi (kid), Altair (flyper), Deneb (tail) Besides these there are technical terms such as azimuth, nadir and zenith which are Arabic in origin.

During Caliph al-Mamun's reign the translation work became a government sponsored activity. Translators worked in groups, each supervised by an expert and assisted by a copyist. The earliest translations into Arabic were the works of Euclid, Ptolemy's Almagest, and the physics of Aristotle. The first translations were not made from original Greek but from Syriac and Persian versions. In the case of many difficult passages in the original the translation was done word for word, and when no Arabic equivalent was available the Greek term was simply transliterated with some adoption. (3) Works translated from Syriac were checked against the Greek originals when possible. And Arabic translations were revised by competent scholars in the light of newly acquired manuscripts.

Some of the prominent translators of this period were Ummayad prince Khalid bin Yazeed(704),ibn Masawaih (857) al-Kindi (873), Hunain ibn Ishaq, Isa b. Ali (925), Hubaish abul Hassan (912), Isa ibn Yahya (987), abu Yakub Ishaq (910) and Kosta ibn Luka (864-923). There was one Persian by the name of ibn Nawbakht, who made translations for Caliph Haroon from Pahlvi into Arabic. Al-Fazari was an Arab whom Caliph Mansur ordered to work with an Indian from Sind on the translation of *Sindhind*  from Sanskrit. There is a general consensus that some of the Arabic translations of the ancient Greek texts were more correctly transmitted,  than those which had been done by Latin translators. For instance, Galen's anatomy was far more accurately described in Arabic than any previous translation.

The age of translation lasted for about a century (850), thereafter original scientific works in Arabic began to appear. This made Baghdad an unparalleled  scientific capital of the world. The independent work done by Muslim scholars and scientists in medicine, mathematics, astronomy and geography was far more conspicuous than in philosophy. Prof Neuberger states that " these Arabic translations are even  today of great value, partly for exegetical reasons, partly because they fill many of the gaps in the ancient literature. ( 4)

**Outstanding mathematicians**

Islamic mathematics  can be divided into four parts (A) an arithmetic derived from India and based on the principle of position (B) an algebra which though came from Greek, Hindu and Babylonian sources assumed a new and systematic form (C) a trigonometry to which Muslims applied the Hindu form and added new functions and formulas (D) a geometry which came from Greece but to which Muslims contributed generalizations. The Muslim mathematicians were, however, more attracted to algebra and trigonometry than to geometry, but one aspect of geometry held a special fascination for them, namely the proof of Euclid's fifth postulate.

Abu Jaffar Muhammad ibn Musa a**l-Khowrzimi** ( 790-850) was born in Khowrzam ( now Khiva in Uzbekistan). His most important work was '*Kitab al –Mukhtasar* fee *Hisab alJabar walMuqabala* ( Compendius Book on calculation by completion & Balancing) written in 830 AD which gave us the word algebra.  This treatise classifies the solution of quadratic equations and gives geometric methods for completing the square. No symbols were used, everything was expressed in words, and no negative or zero co-efficient were allowed. This book was translated by Gerard of Cremona who described it as ' the cornerstone of the mathematical edifice built by the Arabs." Algebraic calculus, Arabic numerals (0-9, in fact Indian), and decimal arithmetic was introduced into Europe through this book.

Al-Jabr was commonly applied to later works in Arabic on the same topic, hence the English word algebra.  The book remained a principal text book in several European universities upto eighteenth century.  A manuscript can be seen at Bodleian Library, Oxford, I 918, 1.

His work on arithmetic '*kitab aljama watafriq bil Hisab al Hindi'* was also translated into Latin by Italian scholar Gerard of Cremona in 12th century.  In Latin this book is called ' *algorithmic de numero Indorum* 'and is preserved in the university library of Cambridge, UK. An English version with Arabic text ' Algebra of Muhammad ben Musa' was produced by Frederic Rosen in 1831 from London, and New York 1969.

When al-Khowrzimi arrived in Baghdad, he wanted to become member of its Institute of Science, therefore, he wrote a dissertation on mathematics and sent to the academy. After some questioning by its members and approval, he was made a member and subsequently became its director. Incidentally, this method of selection is still employed  in universities for post graduate students.(5)  On Caliph al-Mamoon's urging he wrote  another book, *Ilm ul-Hisab*, which has been rendered into many European languages.

He introduced Hindu-Arabic numerals probably after his travels in India. The Arabic text is lost but Latin translation of his book, *Liber Algorismi*, gave rise to the word algorithm, a corruption of his last name.

The first use of zero as a place holder in positional base notion was due to him. He developed the calculus of two errors, which led him to the concept of differentiation. He also refined the geometric representation of conic sections. During his tenure as director of the Baghdad academy of science he (**Baitul Hikmat**) participated in a study which was intended to determine the size and circumference of the earth. In his book in geography '*Kitab Suratul Ardh'* (Form of the Earth) composed in 817, he corrected Ptolemy's views and presented his own planetary model. A text of this book was published from Leipzig in 1926. In 830 seventy geographers worked tirelessly under his able leadership to produce the first map of the then known world for Caliph al-Mamun.

His work in astronomy was *Zij al-sindhind,* which is the first astronomical work to survive in its entirety. He prepared astronomical tables (ZIJ) the first of its kind in the world. The Zij was translated into Latin (1126) by English scientist Adelard of Bath, serving as a basis for all future planetary tables in Europe. He prepared for al-Mamun an atlas of the maps of heaven, which is preserved along with the text. Another work that has survived in *Istikhraj Tarikh al-Yahud*( Extraction of the Jewish era). It is accurate and well informed. He wrote two books on astrolabe, *Kitab amal al-Astrulab* (on the construction of the astrolabe), and *Kitab al-amal bil –Asturlab* ( on the operation of the astrolabe), manuscripts are in Berlin library - arab # 5790 & 5793. *Kitab al-Tarikh* (Chronicle) written in 826 did not survive.

He was no doubt father of astronomy and algebra.

**Umar ibn al-Tabari (** Baghdad 762-812) Umar was the early Persian scholar who was employed at the Abbasid court in Baghdad for translating Pahlavi scientific texts into Arabic. He worked with a group of astrologers, including Nau Bakht, Mashallah, and al-Fazari. His son Abu Bakr Muhammad was also an astrologer and wrote extensively on astronomy. Umar produced following works: (1). A Tafsir of Ptolemy's Tetrabiblos. This is preserved in Uppsala University Library, Sweden, MS Arabic 203. (2)
Mukhtar Masail al-Qaysarani in 138 chapters. Many manuscripts are preserved, one is at Escorial Ar. 938, and Berlin Ar. 5878. (3) Kitab feel Mawalid ( book of Nativities) (4) Kitab al-Ilal.

2) **Hunayn ibn Ishaq** al-Abadi (808-873): He was born in al-Hira (near Baghdad). He was a Christian who studied medicine in Baghdad and traveled to Greece to learn Greek language. He collected many Greek medical manuscripts and translated 139 works, besides supervising the activities of other scholars by revising their translations. He composed his own works as well, i.e.*Questions on Medicine.* As director of Baghdad institute of science, he is said to have received from Caliph al-Mamoon the weight of gold of every book he had translated. (6) Manuscripts of his translations are preserved in the famous Aya Sofya library of Istanbul.

Hunayn was not only a gifted translator but a great linguist also. He coined many of the Arabic scientific terms and identified the Greek names of drugs with Arabic & Persian equivalents. He held the post of chief physician at the court of Caliph al-Mutawakkil (847-861) for most of his life. The Caliph entrusted him with the work of translation in which he greatly distinguished himself. He was assisted with a considerable staff in translating all the known Greek scientific works into Arabic. In particular he translated Plato and Aristotle. He and his gifted nephew Hubaish translated corpus of Galen, and the Aphorisms of Hippocrates. Galens works in Greek origial are lost, but thanks to his efforts, they are preserved in Arabic translations. His Latinized name is Joannitius. His treatise on the eye '*Ten Treatises on the Eye' is the* earliest known systematic textbook of ophthalmology. Caliph al-Mutawakil imprisoned him for one year for refusing to concoct a poison for an enemy.

Hunayn wrote an introduction to Galen's book *Ars Parva* that was immensely popular. He also wrote a Syriac grammar and a lexicon *'Explanation of Greek words in Syriac'*. He translated Old Testament from Greek. He had two sons Daud and Ishaq, Daud (d910)was a physician but Ishaq followd in his fathers footsteps. His work was continued by ninety pupils, chief among them was his son Ishaq (d910) and sister's son Hubaysh, Sabit ibn Qurra and Kosta ibn Luka.

Hunayn possessed the best knowledge of Greek in his time, when a cultural mission was sent to Byzantium to acquire Greek manuscripts, he was made member of this mission. He made several long journeys to find MSS in Syria, Palestine, Egypt, and Bilad al-Rum. Besides medicine he treated other scientific subject in these books: Kitab Khawas al-Ahjar ( Properties of the Stones), Kitab al-Filaha ( on agriculture), Maqala fil alwan ( on colors), Fee al-Daw wa Haqiqatih (on light and its nature) Maqala fil Maddo Jazar ( on ebb and flow), Maqala Afal al-shams wal Qamar ( on the effects of sun and moon), Maqala fee Qaws wa-Quzah ( on the rainbow).

In his youth he wrote translations in his own hand, later his copyists transcribed for him. It was written in Kufic script, lines far apart on thick paper of great size. His research methods of translations are exemplary. His first translation was "on the type of fevers" which he did when he was not even 17.

Hubaysh was the most prolific translator of medical texts from Syriac into Arabic. He translated 35 works from Syriac into Arabic.

Abbas **al-Jawhari** (d830): **He was court astronomer** of al-Mamun in Baghdad. He took part in the astronomical observations and was in charge of the construction of instruments. He wrote books in mathematics and astronomy. Kitab Tafsir Kitab Uqlidis (commentary on Elements), Kitab al-Ashkal and Kitab al-Zij. None of these works have survived. His proof of Euclid's postulate was the earliest written in Arabic.

**Yahya ibn Mansur** (d832) : He was a member of an important family Persian astronomers. He entered in the service of Caliph al-Mamun and became an official at the famous academey of science Baytul Hikma, controlling funds for astronomy. He taught the famous Banu Musa broehers, and died in Aleppo, Syria while accompanying the Caliph on an expedition.

He was appointed director of the group of scholars who established an observatory in the Shamsiyya quarter of Baghdad, and the observatory in Damascus. These two centers of astronomy were intended to make fresh and accurate observations and calculations to correct the existing astronomical tables.

Yahya's team of scientists included al-Khawarizmi and Sanad bin Ali who was in charge of improving astronomical instruments. The group also included Banu Musa borthers and al-Jawahi. The group measured one degree of the meridian by measuring the dip of the horizon, with an astrolabe, from the top of a mountain. This method was used by Sanad bin Ali for the first time. The results were recorded in the Zij al-Mumtahan ( Latin. Tabulae Probatae). A written copy of this research was deposited at the library of the caliph's palace in Baghdad. Only one manuscript ( Escorial Number 927) is known to contain these tables. Yahya's tables exerted a deep influence on later astronomers such as Sabit ibn Qurra who wrote an introduction to these, Ibn Younus Misri adopted them for use in Egypt, and al-Zarqali of Spain made extensive use of them.

**Ishaq ibn Hunayn (d910.** Baghdad) He was son of famous translator Hunayn, like his father he was a physician. He knew Syriac and Greek, his knowledge of Arabic was superior to his father. His son Dawud ibn Ishaq became a translator also. Ishaq's famous work *Tarikh al-Attiba, (History* of Physician) was translated by Franz Rosenthal. His notable contributions are translations from Syrian and Greek. He translated several medical works of Galen that were revised by Sabit ibn Qurra. In philosophy he translated into Arabic Aristotle's works, in mathematics he translated Euclid's *Elements, Optics, Data*, Ptolemy's *Almagest*, and Archimede's *On the Sphere and the Cylinder*.

Besides translations he revised translations made by his colleagues, i.e. he revised Isa Ibn Yahya's "On Anecdotes of Prognosis". His father revised some of his translations. He completed the translation of "on the parts of medicine" which his father was engaged in before his death.

(3) Yaqoob ibn Ishaq **al Kindi** ( 801-873) : He was born in Baghdad. His father was governor of Kufa, Iraq. Caliph al-Mamun and al-Muatasim (833-842) held him in high esteem due to his learning.
He made contributions to the Arabic system of numerals and authored four books on the number system. He contributed to spherical geometry while assisting al-Khowrzimi in astronomical studies.

His work provided the foundation for modern arithmetic. He wrote a book in geometrical optics which inspired Roger Bacon(d1294) . AlKindi wrote 266 books(7 ), thirty two of which are in geometry, eleven in arithmetic, four in number system, thirty-six in medicine, fifteen on music, twelve in physics and two on measuring proportions and time. Few books however have survived the ravages of time. He made many translations from the Greek into Arabic. A Western scholar Cardano has called him one of the twelve great intellectual figures of humanity.

Al-Kindi was the first philosopher of Islam who opened the way for allegorical interpretation of Quran when he interpreted worship in passages 55:6 & 22:18 meaning laws of nature. He was a top-noch musician who is said to have cured neighbour's paralysed son through the use of music.

His books include Ikhtiyrat, Ilahayat Aristu, Mado-jazar, Adviya Morakkabah, al-Mosiqa, and Risala dar Tanjim. These books were translated into Latin by Gerard of Cremona.( 1114-1187).

(4) **Musa Bin Shakir** lived in Baghdad (d 834) He was a mathematician who had three sons who were also able mathematicians. All of the sons were protege of al-Mamoon when they were young. They all received their education at the academy of science, Baitul Hikmat. (a) **Muhammad ibn Musa Shakir** (d872) was an able astronomer, philosopher, and a mathematician. He met Thabit ibn Qurra in Harran during a military expedition and brought him to Baghdad. He invented a chemical balance which is still in use. He traveled to Greece to collect astronomical and mathematical manuscripts. (b) **Ahmad ibn Musa Shakir** (d858) was a competent mathematician and was interested in mechanics. He invented a water-clock which was sent by al-Mamun to Emperor Charlemagne

of France. This water-clock was made of leather & damascened brass; it told the time by metal cavaliers who at each hour opened the door, let fall the proper number of balls on the cymbol, and then, retiring closed the door. ( Age of faith, W. Durant, page 207) (c**) Hassan ibn Musa Shakir** (d873) was a royal astronomer of al-Mamun and al-Mutawakkil. He was a patron of science who gave generous financial support for translations and old books.

All three sons wrote several books of which we mention a geometry book '*Kitab Marifat Misahat al-Ashkal'* containing the well-known formula for the area of a triangle expressed in terms of its sides. This book was translated by Gerard of Cremona who all in all translated 71 scientific works from Arabic into Latin during his stay in Islamic Spain. This book introduced to the Western scholars (Fibonacci, Bacon) the first ideas of higher mathematics.

(5) Abul Hassan **Sabit ibn Qurra** (836-901) : He was born in Harran (now in Turkey) and died in Baghdad. Sabit obtained his mathematical training in Baghdad. He returned to Harran but his liberal philosophies led him to a religious court appearance when he had to recant his heresies. He left Harran to avoid persecution and returned to Baghdad where he was appointed court astronomer of Caliph al-Mutadid (892-902).

He founded the school of translation and rendered many Greek texts into Arabic like Ptolemy's Almajest, Euclid's Elements, Appolonius's book on conic sections and some of Archimedes works. He is considered one of the greatest translators from Greek into Arabic. In fact many Greek works survive today because of his assiduous work in this field. He revised many translations made by Hunayn. He was well-versed in Greek, Latin, Syriac and Arabic. Sabit's school of translation included his son Sinan (860-943)
two grandsons and a great-grandson.

Sabit was instrumental in extending the concept of traditional geometry to geometrical algebra
And proposed theories that led to the development of spherical trigonometry, integral calculus and
Real numbers. He proposed improvements to Euclid's theorems. He studied several aspects of conic
section, notably those of parabola and ellipse. A number of his computations aimed at determining
the surfaces and volumes of different types of bodies constitute the processes of integral calculus.

He gave a generalization of the Pythagorean theorem that is applicable to all triangles. He discusses parabolas, angle trisection, and magic squares which have talismanic values. His most important contribution is to amicable numbers, that is two numbers who are each the sum of the divisor of the other.
He proposed improvements to Euclid's theorems and studied several aspects of conic sections, notably
those of parabola and ellipse. A number of his computations aimed at determining the surfaces and volumes of different types of bodies constitute the processes of integral calculus. He proposed theories
in his book *Masail al-jabar bil-braheen il- Hindsiyya that* led to the development of spherical trigonometry, integral calculus and real numbers.

Thabit added a ninth sphere to the eighth previously assumed in Aristotelian-Ptolemic astronomy. Thabit also proposed a 'trepidation of equinoxes' in a reciprocal type of motion. The echo of his scientific views especially regarding the theory of trepidation was heard throughout the middle ages. He wrote a treatise on astronomy, " *Concerning the Motion of The Eighth Sphere'*. He also published observations of the sun and explained his method . His millenary was celebrated in Iraq in 1962.

For further reading: The Astronomical Works of Thabit ibn Qurra, by F.J. Carmody, Berkeley, 1960, USA. A tract written by his son Ibrahim detailing his fathers work in astronomy is preserved at Khuda Baksch Oriental Library, Patna, Bankipore. # 2468

(6) **Ahmad ibn Yousuf** ( 835-912) : He was born in Baghdad and died in Cairo. He wrote a treatise on ratio & proportion and it was translated into Latin, by Gerard of Cremona. The book is largely a commentary on and expansion of Book V of Euclid's Elements.

He also gave methods to solve tax problems which appear in Italian mathematician Fibonacci's (1170-1250) book '*Liber Abacci'*. He was also quoted by Jordanus (1225-1260) and Italian scholar Luca Pacioli (1445-1517).

(6A.) Abu Bakr **al-Wahshiyya** ( 860-935): He flourished in Baghdad at the peak of its scientific learning and was a contemporary of Zakariya al-Razi. His best known work was al-Filaha al-Nabatiyya
(on agriculture) and al-Sumum wal-Tiryaqat ( on poisons and their antidotes). Later was transalted into English by Martin Levy, Medieval Arabic Toxicology. MSS of both these books are at the national libraries of Algiers, Cairo, Berlin, Paris, Istanbul, and Bodleian at Oxford. He also wrote works in astrology, botany, and magic.

(7) **Abu Kamil** (850-930) Shuja ibn Aslam ibn Muhammad ibn Shuja: an Egyptian mathematician sometime known as al-Hasib al-Misri. He was the greatest algebraist of Islam after al-Khowrizmi. A MS of his

book, *Kitab al-Taraif fil Hisab* ( Book of rare things in the art of Calculation) is extant. The book deals with integral solutions of some indeterminate equations.

In geometry his book *Kitab al-Mukhammas wal al-Muashshar* (on the Pentagon & Decagon). The book contains solutions for a fourth degree equation and for mixed quadratics with irrational co-efficients. The text was utilized, by Leonardo Fibonaci (1175-1220), by copying examples from his work in his book Practica Geometrica. He was the first Muslim to use powers greater x2 with great ease. Abul Wafa translated his work Into Arabic in 998.

(8) **Ahmad Abdullah al-Hasib** died in 830. He was a remarkable mathematician who did research in trigonometry. He was called al-Hasib (mathematician) due to his proficiency in mathematics.
He was an expert in geometry as well. He introduced cotangent, secant and trigonometrical tables.

(9) **Hajjaj ibn Yousuf ibn Mattar** died in 833. He is credited with the translation of Ptolemy's book on astronomy *Megala Syntaxis* under the title **al-Majisti**. The Greek original of this book was lost and its Arabic translation served as source for future editions. He was the first translator of Euclid's Elements (*Kitab al-Majisti*) which was made in 830 on the basis of a Syriac version. He was an expert in geometry and wrote a book *'Muqaddamat Aqleedas'* that was translated into Danish in 1893. He lived in Baghdad during the caliphate of Haroon and Mamun ar-Rashid.

(10) Muhammad ibn Jabir **al-Batteni** (850-929) : He was born in Harran Syria and died in (Qasr al-Hidhr (Samaora) , Iraq. He was mainly interested in astronomy. He is sometimes called a Sabian 'worshiper of stars'. He was one of the greatest astronomer of Islamic world.

He made his accurate astronomical observations at Antioch and **al-Raqqah** in Syria. He catalogued 533 stars. He refined the existing values for the length of the year which he gave as 365 days, 5 hours, 48 minutes, and 24 seconds. He calculated 54 degree.5" per year for the precession of the equinoxes and obtained the value of 23 degree and 35' for the inclination of the eclipitc. His famous book was *Kitab al-Zij*, an astronomical treatise with tables, which was translated into Latin by Plato of Tivoli, in the 12th century under the title "*De Motu Stellarum*". First edition of Zij was published from Nuremberg in 1537 and second edition from Bologna 1645 entitled *Die Scientia Stellarum*. An Arabic manuscript is extant at Madrid's Escorial, Real Bibliotheca, arabe 908, and a Spanish version is at Bibliotheque de l'Arsenal, Paris 8322. The third chapter of the book is devoted to trigonometry. In the Zij he mentioned that he observed two eclipses, one solar and one lunar while in Antioch on 23rd January 901 and 2nd August 901. His fame in the world rests on this book.

Many medieval writers like Henry Bate(d1310), Albert Magnus, Levi Ben Gerson, Regiomontanus, made ample use of al-Zij, giving its author due credit. Frequent references are found in Tyco Brahe's writings, Kepler, Galileo made use of al-Batteni's observations in their earlier works. C.A. Nallino, the Italian scholar, published complete Arabic text of *Zij* from Rome in 1899. A new Latin translation, & commentary by the same author was published in 1903, " which stands as one of the masterpieces of the history of science". ( Dictionary of Scientific Biography, Vol 7). Copernicus quoted him fairly well in dealing with the problems of solar motion and of precession. He expressed his indebtedness to al-Batteni in his book '*Die Revolutionibus'*. He did not believe in the trepidation of the equinoxes, although Copernicus held this erroneous notion six centuries later.

He made many observations of such precision that he was able to demonstrate the existence of annular eclipses of the sun, and many centuries later (1749) enabled Dunthorne to determine the secular acceleration of the movement of the moon. (8) Dr. S.H. Nasr has stated in Science and Civilization, that al-Batteni discovered a new method for determining the time of the vision of the new moon, and made a detailed study of solar and lunar eclipses, used by Dunthorn in his determination of the gradual change in lunar motion. (Page 170)

He used an astrolabe to make observations of planetary movements for 41 years. From these observations he formulated astronomical constants & put these into a ZIJ ( table giving position of stars & planets). He wrote about how he arrived at his figures so that others could use these methods. Thus al-Batteni established a procedure which is now an important part of modern science. Robert Chester, about 1149, by adapting the astronomical tables of al-Batteni & al-Zarqali brought Arabic trigonometry to Engalnd.

In his book *Science of Stars* he mentioned the motion of Sun's apogee. He discovered that the sun's eccentricity was changing ( in modern terms, that the earth's orbit is a varying ellipse). In this work angles are determined by the sine of the angle. (9) In the book *Der Mond*, Beer and Medler have mentioned that one of the surface feature of the moon is named after al-Batteni, which is plain eighty miles in diameter in Section 1, surrounded by high mountains.

He showed that the farthest distance of the sun from the earth varies and as a result, annular eclipses of the Sun are possible as well as total eclipses. He used trigonometrical methods rather than geometrical methods as Ptolemy had done, which was a landmark advance. He wrote a treatise 'On the motion of the stars' which, in addition to astronomical tables, gives important trigonometric formulas such as

$$b \sin(A) = b \sin (90-A)$$

This treatise was translated into Latin 1116, into Spanish in 13th century while a printed edition appeared in 1537. He has been listed amongst the twenty important astronomers of the world. He was the first person to use in his works the expression 'sine' and 'cosine' ( *watar ma yabqa li-taman*). He discovered trigonometrical ratios, and invented sine( *watar raji*), cosine, tangent and cotangent.

Among his worthy achievements is his improvement of the moon's mean motion in longitude, his measurements of the apparent diameters of the sun and the moon and their variations in the course of a year from which he concluded that annular solar eclipses must be possible. He devised an elegant method of computing the manitude of lunar eclipses . His other noteworthy books are: *Kitab Matali al-Buruj*( on the ascension of the signs of Zodiac), *Kitab Aqdar ;al-Ittisalat* (on the quantities of astrological application), *Sharh Kitab al-Arbaa li-Batlamiyus* (commentary on Ptolemy's Tetrabiblos). As son of an instrument maker, he also devised a new type of armillary sphere.

He used ingenuous solutions for some problems of spherical trigonometry using methods of orthographic projection. He used trigonometric ratios as we use them today. He was the first scientist who replaced the use of Greek chords by sines. He also developed the concept of cotangent and furnished their tables in degrees. He used this table in astronomical computations. He knew the relation between the sides and angles of a spherical triangle.

(10a) Abu Mahmud **al-Khujandi** ( d1000) He was outstanding Iranian mathematician and astronomer. He lived under the patronage of Buwayhid ruler Fakhru Dawla (976-997). He was an expert instrument maker also.

He authored following important works. (1) *Risala fil mayl wa-Ard balad* ( obliquity of ecliptic and the latitudes of the lands) 2. *Text of geometry* 3. *Fi amal al-Ala al-Amma* ( comprehensive instrument)

According to Nasiruddin Tusi he discovered the **Qanun al-Haiya**, the sine theorem relative to spherical triangles. Abul Wafa Buzjani also claimed to have discovered this theorem. Al-Tusi has given Khujandi's solution related to the sine theorem in his book *Skakal al-Qatta*. Khujandi constructed on a hill Jabal Tabruk near Rayy an instrument *al-Suds al-Fakri* ( sixth of a circle) for the measurement of the obliquity of the ecliptic. Al-Biruni states that on this instrument each degree was subdivided into 360 equal parts and each tenth second portion was distinguished on the scale. An instrument like this one was constructed at the Maragha observatory in 1261.

Al-Biruni states that Abu Sahl al-Kuhi (tenth century) constructed a dome building with an aperture on the top. Sun rays entered through the aperture and traced the daily trajectory of the sun.
Khjandi's instrument was so huge that the aperture sank by about one span. In order to read the smaller fractions of a degree, Muslim astronomers increased the size of their instruments. Ulug Beg was other astronomer who built huge instruments.

He built an armillary sphere and other instruments for the observation of the planets. He built a universal instrument al-Ala al-Shamila (comprehensive instrument) which was used instead of the astrolabe, but it could be used for one latitude only. After observing sun and the planets he determined the latitude of Rayy. These observations were made in the presence of distinguished astronomers. Based on these observations he compiled Zij al-Fakhri. A manuscript of this Zij (MS 181) is preserved at the Library of Iranian parliament in Teheran.

For further reading: Observatory in Islam,. By A. Sayily, Ankara, 1960. Risala al-Khujandi by L. Cheiko, Beirut, 1908. Geschichte der Mathematik by M Cantor, Leipzig 1880. Studien zur Astronomie der Araber by O. Shirmer, 1926.

(11) Abul Abbas **Al-Farghani** (d870.Egypt) : He was employed by Caliph al-Mamoon. He was a renowned astronomer/astrologer and an engineer. He supervised the construction of *al-Miqyas al-Kabir* (Great Nilometer) at al-Fustat( Cairo). It was completed in 861. He was a theoretical rather than a practical engineer. Sanad ibn Ali, another engineer, was his contemporary who assisted him in the digging of a canal near Baghdad.

His book in astronomy *Jawami ilm al-Nujum* or Elements of Astronomy was his most influential work. Two Latin translations were made in 12th century, one by John of Seville in Spain in 1135 and other one by Gerard of Cremona in 1175. Printed editions of Elements appeared in 1493, 1537, 1546 and Gerard's in 1910. Jacob Anatoli made a Hebrew translation also, while Jacob Golius published Latin text with Arabic original in 1669. There are numerous Latin MSS in various European libraries.

His other books are *Ikhtiyar al-Majisti* (summary of Almajest), *Kitab amal al Rukhamat* (constuction of sundials), & *Kitab amal al Asturlab* ( use of astrolabe) a 13th century manuscript of which is stored at British museum. ( No. 5479). *Dictionary of Scientific Biography, NY 1972, Vol 4.*

He has been called one of the greatest astronomers who ever lived. *The Elements of Astronomy* deals chiefly with celestial motion. This book was predominant in European astronomy.

Famous historian, Paget Toynbee showed Dante's indebtedness to al-Farghani in the *Vita Nuova* and *Convivio*. After comparing selected passages and key captions in these works with selection from the Elements of Astronomy, Toynbee, concluded that in the *Vita Nuova* Dante borrowed material dealing with comparison of the planets, and that Dante's discussions of the distance of Venus from the Earth, of poles and equators, of fixed stars, are based on al-Farghani's writings. *The Divine Comedy, too*, follows al-Farghani's astronomy, representing the eight revolving heavens approximately on the same scale of the logarithms of their dimensions estimated by al-Farghani. (Toynbee in Dante Studies and Research, London, 1902 pp56-77. Quoted in *Arabic Thought & the West,* by Eugene Myers, New York, 1964, page 12)

(12) Ibn Sinan ibn Thabit ibn Qurra **IBRAHIM** : He was born in Baghdad. He was grandson of famous mathematician Sabit ibn Qurra. He studied geometry and in particular tangents to circles. He also studied the apparent motion of the sun and the geometry of the shadows. His most import work was on the quadrature of the parabola where he introduced a method of integration more general than that of Archimedes(d 212BC). Ibrahim is also considered the foremost Arab mathematician to treat mathematical philosophy. His works amply prove that Muslim mathematicians developed mathematics independently.

His famous works are: Rasail Ibn Sinan, (Hyderabad 1948), Fil Usturlab, al-Tahlil wal Tarkeeb ( analysis and systhesis), Fee Harakat shams ( on solar movements), al-Handasa wa-Nujum (geometry & astronomy).

Ibrahim's father Sinan ibn Sabit is reputed to have given medical diplomas to 800 physicians to practice medicine in Baghdad.

(13) Abdur Rahman **al-Sufi** al-Razi ( 903-986 Iran) His Latinized name is Azophi. He is most famous for his observations and descriptions of the fixed stars. His book *Kitab Suwar al-Kawakib al-Sabita* (Book on the Constellations of the Fixed Stars) contains the results of his observations in addition to a critical revision of Ptolemy's star catalog. In fact this was the first revision of Ptolemy's findings in Islamic astronomy. The book was widely read in Europe during the medieval period. Instead of repeating the Ptolemaic star catalog, al-Sufi provided records of real star observations, adding constant values to his longitudes. He also gave exact astronomical identification of the several hundred old Arabic star names that were previously transmitted in Islamic works. He identified these stars astronomically. His identifications were later adopted by Muslim and European astronomers. For instance G. Piazzi selected 94 star names and introduced them into general use through his book "Stellarum Inerrantium" (1814). T.Hyde quoted al-Sufi several times in the commentary to his edition of Ulug Beg's star catalog.

He wrote a detailed book on the construction and use of an astrolabe, *Kitab al-amal bil Asturlab*, published from Hyderabad, India in 1962. *Introduction to the Science of Astrology*, and a *Book on the Use of Celestial Globe* are also noteworthy. . He constructed many astronomical instruments, a silver celestial globe made by him was preserved in Egypt in 1043. He wrote a poem on the constellations, *Urjuza fee suwar alKawakib al-Sabita.* The Arabic text of his book was published alongside the Urjuza from Osmania University, Hyderabad, India, 1954. Nasiruddin Tusi translated his book into Persian in 1250, but is still unpublished. A Castillian translation was made by order of King Alfonso X of Castile, around the middle of thirteenth century, published in 1863 from Madrid.

A Muslim author Ibn al-Salah as well as al-Biruni wrote an Arabic criticism of his works. A sky map, including the Arabic stellar nomenclature according to al-Sufi was printed in Algiers in 1881 in French.

(14) *Muhammad* **Abul Wafa** Al-Buzjani ( 940- 998): He was born in Buzjan (near Jam, Iran) and died on 15th July 998 in Baghdad. He was the last scholar who did translations from Greek into Arabic. Abul Wafa conducted astronomical observations at the Baghdad observatory of Sultan Sharfu Daula. His instruments in the observatory included a quadrant over six meters long and a stone sextant of 18 meters. He is said to have been the first to build a wall quadrant to observe the stars.

He translated and wrote commentaries on the works of Euclid and Diophantus and al-Khowrzimi. He also proved theorems on plane geometry and spherical geometry that were applied by astronomers and geographers. He commented on Khowrzimi's algebra and translated from the Greek one of the last classics - *the Arithmetica* of Diophantus.

Abul Wafa devised a new method of calculating sine tables. His trigonometric tables are more accurate than Ptolemy's. He is best known for the first use of tan function and compiling tables of sines and tangents at 15' intervals. This work was done as part of an investigation into the orbit of the moon, written down in the 'theorems of the moon'. He also introduced the secant and cosecant and studied the inter-relations between the six trigonometric lines associated with an arc. His large astronomical work '*Kitab al-Kamil'* is in fact a simplified version of Ptolemy's Almagest. Manuscript of this work is at Bibliotheque Nationale, Paris, Ar 2497. His other books are *'Ilmul Hisab'*, (961) a practical book on arithmetic, and 'Kitab al-*Hindsiya*' (990) on applied geometry. Manuscripts of Ilmul Hisab are at Univesity of Leiden, # 993, and National Library, Cairo. In geometry his contribution comprises of solution to geometrical problems with opening of the compass, construction of a square equivalent to other squares, regular polyhedra, construction of regular hectagon and parabola.

His contribution to the development of trigonometry was of fundamental nature. He was the first person to show the generality of the sine theorem relative to spherical triangles. He developed a new method of constructing sine tables, the value of sin 30' being correct to the eighth decimal place. He knew the relation between the trigonometric lines, which are now used to define them, and undertook studies on conics. In geometry his major contribution is solution of geometrical problems with an invariable opening of the compass construction of a square equivalent to other squares, regular polyhedra, construction of regular hectagon and parabola.

He calculated a table of tangents. Abul Wafa introduced the following formula for the additions of angles - **sin (a+b) = sin a cos b + cos a sin b** - which was rediscovered by a pupil of Copernicus, **Rheticus.**

Abul Wafa's name is linked with one of the fundamentals of astronomy, that of the third inequality of moon. (10). Unfortunately this discovery has been wrongly attributed to Tycho Brahe.

He wrote a commentary on al-Khworzimi's algebra, and solved the fourth degree equation x4 + px3= q by means of the intersection of a parabola and hyperbola.

(14A) **Kushyar,** abul Hassan al Jili (d 1000) He made his name in astronomy, trigonometry and arithmetic. He was from the northern region of Jilan, Iran. He composed two sets of Zijes, **al-Jami** (the comprehensive) and **al-Baligh** ( the Far Reaching). A MS of al-Baligh is at Berlin while al-Jami is at University of Leiden. In arithmetic he wrote *Usul Hisab al –Hindi* (Elements of Hindu Reckoning- MS at Aya Sofia Library, Istanbul). He also wrote *Kitab al-Asturlab wa Kayfiyyat amalihi wa Ittibarihi* ( A book on the astrolabe and how to prepare it and test it – MS at Bibliotheque Nationale, Paris # 3487.)

His other books are *Tajrid Usul Tarkeeb al-Juyub* ( Extracts of the Principles of Building up sine tables), *al-Madkhal fee sinaat ahkam al-Nujum* ( Introduction to the rules of astrology and astronomy- MS at Escorial, Madrid# 972 ), *Risala fee al-Abad wal –Ajram (* a treatise on the distances and the sizes – MS at Rampur Library, Patna, India).

His Zijes contain sine, cotangents, tangents, and versed sines together with tables of differences.

(15) Abu Sahal Wejan ibn Rustam **Al-Kuhi** (940-1000): He was born at Kuh in Tabaristan (now Mazanderan , Iran). He flourished in Baghdad. In 969 or 970 he made observations of the winter and summer solstice in Sheraz, Iran. In 988 he organized the building of an observatory to study the planets. He became the director of this observatory and made some accurate observations. It ceased to operate in 989.

He was royal astronomer at Sultan Sharfu Daula's observatory. It should be mentioned that Buwayhid Sultan Sharfu Daula (982-989) built an observatory in the garden of his palace in Baghdad where two assiduous astronomers, al-Kuhi and Abul Wafa observed the course of seven planets.

He worked in geometry and considered problems leading to quadratic or cubic equations. He made a thorough study of trinomial equations. Al-Kuhi also described a conic compass, a compass with one leg of variable length, for drawing conic sections. He devoted his attention to problems leading to equations of a higher degree than the second, he was successful in solving some of them. These investigations are among the best in Muslim geometry. He wrote a book *Additions to the Book of Archimedes , Sphere and Circle.*

Al-Khayyam considered him to be the best mathematician. In his book Risala fil Birkar al-Tamm ( on the perfect compass) he described the method of constructing straight line, circles, and conic sections with compass. Al-Biruni made use of this work. He also produced works on astronomy and a treatise on astrolabe Kitab Sanat al-

Asturlab. He wrote a commentary on Archimedes Lemmata. His work Risala fee Misahat al-Mujassam al-Mukafi ( on measuring the parabolic body) was published by Osmania Oriental Publishing, Hyderabad, Indian in 1948.

(16) Abul Hassan **Ibn Younus** (950-1009) : He was born in Egypt and died in Fustat (Cairo) . Ibn Younus is famed for his astronomical observations, as an astrologer and a poet. He also made many trigonometrical tables, all designed for astronomical observations. He invented pendulum and the sun-dial.

His major work is a handbook '*al-Zij al-Hakemi al-Kebir'* (Hakemite Tables) which was dedicated to Caliph Biamrillah al-Hakem (990-1021) of Egypt. The book has 81 chapters. There are lists of observations made by Younus himself and his predecessors. He described 40 planetary conjunctions accurately and 30 lunar eclipses used by famous US astronomer Simon Newcomb ( 1835-1909) in his lunar theory. These tables, in which many constants were remeasured accurately, are considered to be among the most accurate to have been composed during this period in the Islamic world. He was a leading mathematician at Cairo's Darul Hikmah (academy of science) which lasted from 1005-1171 and whose library was filled 18 halls. It is said that after 17 years of observations he completed Hakemite
Tables of astral movements, & periods and gave more precise value than before to the inclination of the ecliptic, the precession of the equinoxes and solar parallax. ( Age of Faith by Durant,page288)

The only extant chapters of this Zij are in two manuscripts at Leiden and Oxford. In 1804 de Perceval published the text with French translation. Carl Schoy published translation and analyses of several chapters of Zij on sundial theory and spherical trigonometry. The Bibliotheque National in Paris # AR 2496 in an abridgement (Wajiz) of these tables. His house was on Muqattan hills overlooking the city of Cairo, it had astronomical instruments, he made observations of Venus from this house. He also used his great-grandfathers house and the mosque of Ibn Nasr at Qarafa for observations also. On 22 April 981 he observed a lunar eclipse from this mosque.

In addition to this he produced planetary longitudes and calendar tables. Spherical trigonometry reaches a high level of sophistication in his work. He introduced the formula **2cos x cos y = cos (x+y) + (x-y).** This is one of four formulas that in 16th century Europe served before the invention of logrithms to convert products to sums by the method known as 'prosthaphaeris' (Greek for addition and subtraction). He (Azerquil) solved many problems of spherical trigonometry by means of orthogonal projections.

In astrology he wrote a book Kitab Bulugh al-Umniyah ( On the attainment of desires). In astronomy his other major work beside the famous Zij was Kitab Ghayat al-Intifa (very useful tables)
Containing times of Salat with reference to daily motion of the sun across the sky and throughout the year. Manuscripts of these books are at Darul Kutub, Cairo, miqat 108. He also wrote a poem on the times of prayers. Hos poems can be found in medieval Arabic anthologies. Kitab al-Jayb (sine tables) are extant in Berlin Ahlwardt library – 5752.

He was the first person who studied the isometric oscillatory motion of a pendulum – which later led to the construction of mechanical clocks. (Science **& Civilization, by Nasr, page 171**).

Younus was described by his biographer al-Musabihi as follows : " he was an eccentric, careless, absent-minded who dressed shabbily and had a comic appearance." He predicted the date of his own death to be in seven days time when he was in good health. He tidied up his business affairs, locked himself up in his house, washed the ink of his manuscripts, recited the Holy Quran until he died on the day he had predicted.

(16A) Muhammad ibn Moadh **al-Jayyani (990-1079):** Latin Abenmost. He made his name in mathematics and astronomy. He was born in Jaen (Spain). He wrote a treatise "on the total eclipse" which occurred in Jaen on July 1, 1079. He also wrote a treatise "on the dawn" which was translated into Latin by Gerard of Cremona. In his Maqala fee Sharh al-Nisba he is referred to as Qazi. Several of his works in Arabic are extant. Kitab Majhulat Qissiyal Kura is on spherical trigonometry. His astronomical tables Tabulae Jahen were published in Nuremberg in 1549. Ibn Rush regarded him as a high-ranking mathematician.

(17) Abu Ali Alhassan **ibn Haisham** ( 965-1039) : He was born in Basra, Iraq and died in Cairo. He is best known for his **Alhazen's problem** which is " given a light source and spherical mirror, find the point on the mirror where the light will be reflected to the eye of an observer". This problem leads to a quadratic that was solved with Greek style geometry. His magnum opus '*Kitabl al-Manazir'* earned him the title of father of optics. This book was translated into Latin in 1270 as *Opticae Thesaurus Alhazen*, and many prominent European scientists including Leonardo da Vinci (1452-1519), Kepler (1571-1630), Roger Bacon , Newton (1643-1727), benefited from his theories in this field.

Alhazen applied geometry to the study of light. (11) He worked on reflection, refraction, lenses, parabolic and spherical mirrors, spherical aberration, & atmospheric refraction. He wrote on these topics after experimenting with lenses and mirrors. He did his research at Cairo's famous Darul Hikmah.

His study of magnification with lenses led him to conclude that the magnification was caused by the curvature of the lenses. He gave the first correct explanation of vision showing that light is reflected from an object into the eye. His study of refraction led him to propose that atmosphere had a definite depth of about 15 km. His study of optics led him to propose the use of ***camera obscura*** and he was the first person to mention it. He observed the half-moon shape of the sun's image, during eclipses, on the
Wall opposite a small hole in the window shutters, this is the first known mention of the camera
Obscura, or dark chamber, on which all photography depends. ( Durant, Age of faith, page 289)

He explained twilight by refraction of sunlight once the sun was less than 19 degree below the horizon. He studied the motion of a body and was the first person to propose that a body moves perpetually unless an external force stops it or changes its direction of motion. This remarkable theory is strikingly similar to Galileo and, Newton's law of motion.

He came so close to discovering the magnifying lens that Roger Bacon, Witelo and other Europeans three centuries later based upon his work their own advances toward the microscope and telescope. *( Age of Faith by Will Durant, page 288, NY 1950)*

His law of refraction was rediscovered by Deutch scientist **Willebrod Snell** (1591-1626) and is now called, Snell's law, N1SIN1=N2SIN2. He authored close to 200 books, few have survived through Latin translations. He elaborated upon Euclid's fifth postulate, proving thereby that the fourth angle is always a right angle. (for a detailed article on his innovative proof, please visit this site- http://sunset.backbone.olemiss.edu/ ~RPAGEJR/euclid.html).

In his book '*al Shakuk ata Batlymus'* (Doubts about Ptolemy) he argued against some of Ptolemy's (85-165) theories of motion. In mathematics he solved problems involving congruences using
what is now called **WILSON's** theorem. He successfully developed analytical geometry by establishing a link between algebra and geometry. Some of his books in mathematics are - *Sharah Asool Aqleedas, Sharah almajesti wa talkhees, Alkitab aljamah fee asoolul hisab, Maqala fil hisab alhindi, Risala bijameeal Ishkal alhindsiya (on geometry), Maqala fi hal fil aqleedas fil maqala alkhamisa (on fifth postulate).*

In 1795 a Scottish mathematician John Playfair ( 1748-1819) published an edition of Euclid's *Elements* in which he gave an alternative to Euclid's parallel postulate which is now called Playfair's Axiom. This alternative was in fact discovered by Ibn al-Haisham more than 1000 years ago when he stated

**" al-khatane al-mustiqee mane al-mutaqate aane la yo-waziyan khataa wahidaa mustaqeemaa ."**

This should have been called Alhazen's Axiom but Western scholars are not shy of such intellectual robberies. For more details read an interesting article in monthly Tahzeebul Akhlaq, page 25, September 1995, India.

Alhazen "*enunciated that a ray of light, in passing through a medium, takes the path which is easier and quicker."* In this he was anticipating French mathematician **Fermat's** Principle of Least Time
by many centuries. (Ideals & Realities, A. Salam, page 283). It is stated and I have myself read chapter 5 of Roger Bacon's book OPUS MAIUS that is an exact copy of Kitab al- Manazir. A fine example of plagiarism perhaps.

Ibn al-Haisham wrote a book '*Resume of Astronomy'* in which he described the motion of the planets, not only in terms of eccentrics and epicycles, but also according to a physical model, which
Exercised a lasting influence upon the Christian world up to the time of Kepler. It is said that Tusi composed a treatise on the structure of heavens based on Ibn-al-Haisham's aforementioned treatise.

It is mentioned in the famous book Der Mond (1837) that a surface feature of the moon is named after Alhazen. It is the name of a ring-shaped plain the west of hypothetical MARE CRISIUM in
Sction 12. Towards the end of his career he simulated madness to escape ruthless Caliph al-Hakim's rage for failing to regulate the annual flow of the Nile by building a dam near Aswan. To make a living
he often copied mathematical manuscripts and sold them in Cairo where de died.

(16) Abu Nasr **Mansur** ibn Ali ibn Ishaq (970- 1036) : He was born in Khwarzam (now in Uzbekistan) and died in Ghazna (Afghanistan). He was a disciple of Abul Wafa and worked on trigonometry and discovered the sine law: a/sin A= b/sin B = c/sin C. He wrote several short books on specific problems in geometry and astronomy. He taught al-Biruni.

(18) Abu Rehan Muhammad ibn Ahmad **al-Biruni** (973-1048) : He was born on 15 Sep 973 in Kath (now Kara Kalpakskaya, in Uzbekistan) and died on 13th Dec 1048 in Ghazna. He traveled widely, visiting India and studying its culture for 20 years. He became proficient in Indian sciences to the point that Hindu pundits gave him the honorific title of *Vidyasagar ( sea of knowledge*). He learnt mathematics from Mansur, a pupil of Abul Wafa.

Albiruni was an outstanding intellectual figure who contributed profusely to astronomy, mathematics (where he worked on shadows and chords of circle), physics (where he worked on springs or hydrostatics, specific weights of precious stones and metals), medicine and anthropology. His most famous book '*Kitab al-Hind'* (India) was inspired while he accompanied Sultan Mahmud on his Indian campaigns.

His contributions to sciences are of major importance. He believed that earth rotated on its axis, and made accurate calculations of latitude and longitudes. He took it for granted that earth is round, noted "the attraction of all things towards the center of the Earth. "In 1000 CE he wrote on calendars and in 1030 he wrote his masterpiece on astronomy '*Qanun alMasudi Fil Hai wal-Najum'* which contains a collections of 23 observations of equinoxes beginning with observations made by Ptolemy and ending with observations which he made himself. In this book he also discussed several theorems of astronomy, trigonometry, solar, lunar and planetary motions.

He discovered seven different ways of finding the direction of North and South and found a mathematical technique to determine the exact beginning of the season. He rendered into Sanskrit Euclid's Elements and Ptolemy's Almagest. ( 12)

On 8th April 1019 there was solar eclipse and on 17 Sep 1019 there was a lunar eclipse. Both events were observed by al-Biruni. The solar eclipse was seen by him from Lamghan, a valley surrounded by mountains between the town of Kandhar and Kabul. The lunar eclipse observed by him from Ghazna, Afghanistan. He gives precise details of the exact altitude of various well-known stars at the moment of first contact. He made interesting observations on the velocity of light, stating that its velocity is immense compared with that of sound. He described the Milky Way as "*a collection of countless fragments of the nature of nebulus stars*. " Albiruni expressed dimensions of the universe in terms of radii of the earth as follows: Moon 33.33, Mercury 64.20, Venus 169.46, Sun 1161,45, Mars 1260.15, Jupiter 9169.14,Saturn 14881.29, Stars 20774.39.

He was a pioneer in the study of angles and trigonometry. He worked on shadows and chords of circles and developed a method for trisection of an angle. He elaborated on the principle of position and discussed the Indian numerals. His work in mathematics and astronomy is summarized in his book 'Al-*Tafheem li Awail Sinaat Tanjim'*. Ramsay Wright translated it into English in 1934. He studied hydrostatics and made very accurate measurements of specific weights of 18 metals. He is known to have corresponded with famous Persian sage Ibn Sena. He was proficient in Arabic, Persian, Greek, Syriac, and Sanskrit. He observed that flowers have 3,4,5,6, or 18 petals but never seven or nine. He was given the honorific title of "*AL-Ustadh*", teacher par excellence.

As an inventor Alberuni described the construction of a mechanical calendar around 1000 AD. The description occurs in a book devoted to the construction of various types of astrolabe and related instruments. The drawing of this calendarical device can be seen at the British Museum, London.
An Islamist Joseph Schacht has stated that " we have the drawing of a n astrolabe with gears belonging to al-Biruni.... which was forerunner of the mechanical clock." ( 13). Visit the following site on the internet also //www.soas.ac.uk/trial/www.bbk.ac.uk.

In inscribing a nonagon in a circle, al-Beruni reduced the problem, through the trigonometric formula COS30, to solving the equation x3=1+3x, and for this he gave the approximate six place accuracy. He also gave an account of Hindu shadow reckoning. His treatise *Istikhraj alautar fee aldaira* is a geometrical treatise that deals with the theorems concerning the chords in the circle. ( 14)

Did he know that earth rotated around the sun? Dr. Nasr replies to this puzzling question in these words : " Alberuni knew the possibility of the motion of the earth around the sun and even – as al-Biruni proposed, in his questions to Avicenna – the possibility of an elliptic rather than circular motion of the planets. But none of them did, nor could they, take the step to break with the traditional world view because that would have meant not only a revolution in astronomy, but also an upheaval in the religious, philosophical and social domains. " ( page 174)

Al-Beruni had given as a solution to the famous problem of the grains of wheat on the chessboard (that is the sum of 1+2+3+4+8.........) the value 18,446,744,073,709,551,615 which boggles the mind. He gave solution to the problem (called Albirunic) trisection of the angle that cannot be solved with ruler and compass alone. His millenary was celebrated in Karachi and Tehran in 1973.

(19) Abu Ali Alhussain ibn Abdullah **Ibn-e- Sena** (980-1037) : He was born near Bukhara, in Central Asia and died in Hamadan , Iran. Avicenna was the most influential philosopher, scientist, physician, & scholar. He received education from his father, his house was a meeting place for men of learning. He studied logic & metaphysics under some of the best teachers of his time. In particular he studied medicine without a teacher, and cured a Samanid ruler Nuh ibn Masnur, and as a reward was allowed to use the voluminous Royal library. He seems to have devoured its contents before embarking upon his professional career when he was in his twenties.

Avicenna's life took a marked turn after the death of his father and the defeat of the Samanid dynasty. After wandering for a while, he settled down in Hamadan where the ruling prince appointed him vizier. His two most important works are *Kitab al-Shifa* and *al-Qanun fi tibb*. The first is an 18 volume encyclopedia covering logic, geometry, psychology, arithmetic, astronomy and music. The second is the most famous single book in the history of medicine consisting of one million words. In 1022 he left Hamadan and traveled to Isphahan. Here he wrote many works in philosophy, medicine and a dictionary in Arabic language, Lisanul Arab. He was a prolific writer. According to some sources 456 works in Arabic and 23 in Persian are ascribed to him. Approximately 160 of his works can be located in the catalogues of leading world libraries. In the Islamic world he is remembered by his honorific title *Shaikul Raees* ( Leader among Wise Men ) while in the West he is remembered as the *Prince of Physicians*.

At his observatory in Ispahan he made astronomical observations and made correct deductions from them. He invented numerous astronomical instruments. He observed Venus as a spot against the surface of the Sun and correctly deduced that Venus must be closer to the Earth than the Sun. It is reported that on May 24, 1032 AD he observed with naked eye and described precisely a rare phenomenon of Venus. History books wrongly credit English astronomer Jeremiah Horrocks having observed this phenomenon in 1639. Avicenna was the first person who used mathematics for solving problems in physics and astronomy. He also correctly stated that the velocity of light is finite. He wrote commentaries on all of Aristotle's books. He composed a translation of Euclid's Elements. He explained the casting out of nines and its application to the verification of squares and cubes. Like al-Kindi; he applied geometry to the movements of light.

In physics, his contribution comprise the study of different forms of motion, energy, heat, light and such concepts as force, vacuum and infinity. He propounded the connection between time and motion and also made investigation on specific gravity. He used an air thermometer in his laboratory. His treatise on minerals was a main source of European geology until the 13th century. He composed excellent poems, of which 15 have survived.

In his youth he was flamboyant, prone to all night parties. On his deathbed he was gripped by remorse and listened to the reading of Quran for many days. He became seriously sick during one of the military campaigns, & despite attempting to apply his medical skills to himself he died of colic. There is a hospital named after him in Baghdad. In 1950 a mausoleum was built in Hamadan which is visited by millions of his admirers. ( 15)

An American author states that 'the greatest Arabian scientist is almost the sole instance of a great mind applying mathematical concepts to medicine.' (16) . He devised a contrivance the purpose of which was to that of the Vernier, that is to increase the precision of instrumental readings. (17) His scientific views left their indelible mark upon many figures such as Albertus Magnus, St. Thomas Acquinas, Duns Scotus and Roger Bacon. In the Islamic world his spirit has cast a living influence to the present day.

Some of his relevant books are : *Mukhtisar al-Majisti, Mukhtisar al-Aqleedas, Maqala fee hayati Ardh, Maqla fee kaifeeyat ar-Rasad, Qiyam al-Ardh filwast, Maqala fee Ajrami Samawiya.*

(20) Abul Fatah Umar ibn Ibrahim **al-Khayyam** ( 1048- 1122) : He was born in May 1048 in Nishapur, Iran and died in the same city. He was a poet as well as a brilliant mathematician. He discovered a geometrical method to solve cubic equations by intersecting a parabola with a circle. He was an outstanding astronomer as well. At age 22 he was made director of an observatory in Isphahan which helped him immensely to develop the new **Jalali** calendar. The new Jalali calendar started in Iran on 16th March 1079. E. Gibbon says about this new calendar " a computation of time which surprasses the Julian calendar and approaches the accuracy of Gregorian style." This calendar was remarkably accurate as it had an error of one day in 3770 years, it was far superior to Gregorian calendar which has error of one day in 3330 years.

He measured the length of the year as 365.24219858156 days. This shows an incredible confidence in his ability to give the result to this degree of accuracy. It is remarkably accurate.

His work on algebra was studied throughout Europe during the Middle Ages. He also developed the binomial expansion when the exponent is a positive integar. As a matter of fact, he has been considered to be the first to find the binomial theorem and determine binomial coefficients. In geometry, he studied generalities of Euclid and contributed to the theory of parallel lines. Descartes applied the same geometrical approach in solving cubics. His influence in the development of mathematics has been immense.

In his book '*aljabar wal Muqabala'* he referred to another work which is lost. In his lost work he discussed Pascal's triangle which is sometimes referred to as Chinese triangle. His algebra is geometrical, solving linear and quadratic equations by methods appearing in Euclid's Elements. He discovered a geometrical method to solve cubic equations. He did this by intersecting a parabola with a circle. He also gave important results on ratios giving a new definition and extending Euclid's work to include the multiplication of ratios. He wrote little and accepted few students.

His book *Algebra* was translated into French in 1857, its partial solution of cubic equations has been judged "*perhaps the highest peak of medieval mathematics*". Another of his works on Algebra ( manuscript is in Leiden library) studied the postulates & definitions of Euclid.
(**Age of faith, page 321)**

Khayyam's fame as a poet has shadowed his scientific achievements. He is credited with inventing the leap year. His other books are *Risala fee sharah ma-ashkal min maasadirat Kitab Aqleedas, Zij Malik Shahi, Risala Mukhtasar Tabiyaat, Mushkilat al-Hisab, Naoroz Nama, Fee Usul Hisab al-Hind, Risala fil wujud ( on the existence), and Mizanul Hikma. .*

(20A) Abdur Rahman **al-Khazini** (Merv, Iran d.1130) He composed a book of astronomical tables for Saljuk ruler Sanjar ibn Malikshah, and constructed a balance for his treasury. He was an outstanding astronomer, but his expertise lay in making scientific instruments. He was famous for his asceticism, he dressed like a Sufi mystic and " ate the food of pious men". He refused to accept a reward from the Sultan of 1000 dinars on the completion of astronomical tables. He said he had ten dinars, he lived on three per year, for in his household there was only a cat.

His famous works are 1. *Al-Zij al-Sanjar* – book on astronomical tables dedicated to the ruler. The manuscripts of this Zij are Vatican library Ar # 761, and British Museum cod Or # 6669.
2. *Risala fil Aalat* (treatise on making astronomical instruments) A manuscript is Sipahsalar mosque in Teheran. 3. *Wazij al –Zij:* an abridgement of his book on astronomical tables. Treatise on instruments – a manuscript is preserved Vatican library. 4. *Kitab mizan al-Hikma:* book of the balance of Wisdom, dealing with the science of weights, the art of constructing balances, & scales. The hydrostatic balance built by him made the greatest maker of scientific instruments.

As a maker of scientific instruments he is among the greatest of any time. His Zij takes its place after those of al-Biruni and Umar Khayyam. He is among the 20 astronomers who performed original observations.

(21) Abu Bakr **AL-KARKHI** - he lived in Baghdad around 1000 AD. In 1853 his algebra was published by Franz Woepcke (1826-1864) and his arithmetic was translated into German by Hochheim in 1878. He gave expressions for the sums of the first, second and third powers of the first N natural numbers. He busied himself with indeterminate analysis. For solutions of quadratic equations he gives both arithmetical and geometrical proofs. He wrote two books *Kitab al-Fakhri and the Requisite for Arithmetic..*

(22) Shamsuddin **al-Samarkandi** ( d1276) He was a contemporary of al-Tusi and Qutub udin al-Shirazi(d1311) He was best known for his famous tract *Kitab Ashkal al-Tasis* (Book on the Fundamental Theorems). This work summarizes 35 fundamental propositions of Euclid's geometry. Several mathematicians like Kazizada commented on this work. In astronomy he wrote *al-Tadhkira fil Haya* (Synopsis of Astronomy) and a star calendar for years 1276-1277. His book on dialects *Risala fi Adab al-Bahth (* Tract on the methods of Enquiry) was the subject of several commentaries.

(23) Ibn Yahya **al-Samawal** (d1180) He was born in Baghdad and died in Maragha, Iran. With the decline of Baghdad he could not find a teacher, hence he studied arithmetic indepedently.
He studied Euclid, algebra of Abu Kamil, al-Karaji and arithmetic of al-Wasit. His extant book on algebra **al-Bahir** ( the Dazzling) was written when he was nineteen years old. He was the first Arab algebraist to understand the study of relative numbers. The book also deals with number theory. He also wrote other books in mathematics *al-Tabsira* (Brief Survey) and *al-Mujiz* (Summary). It is said he penned close to 85 books, of which most of have been lost. MS of al-Bahir is preserved at Aya Sofya Library, Istanbul, # 2718., a modern edition was printed by S. Ahmad in Damascus in 1972. MS of al-Tabsira is at Bodleian Library, Oxford I, 194. The rules of multiplication and division that he enunciated are still in use today.

He was also a successful physician, he had emirs his patients. In medicine he wrote Nuzhat al-Asbab.

(24) **Nasiruddin Al-Tusi** ( 1201- 1274) : He was born on 18th Feb 1201 in Tus, Khorasan, Iran and died 26th June 1274 at Kazimain near Baghdad. Tusi became astrologer to Ismaili governor and attempted to join the caliph's court at Baghdad but was imprisoned in the fortress of Alamut, which was headquarters of Hasan Bin Sabah's terrorists group alhashisheen - Assassins. In 1256 Tusi betrayed the Alamut defenses to the invading

Mongols and joined Helagu's service. He was rewarded by Helagu Khan with the construction of an observatory at Maragha, Azerbaijan which became operational in 1262. It had various instruments such as a 12 feet wall quadrant made from copper and an azimuth quadrant which was invention of Tusi himself. He designed many instruments at the observatory. The library at Maragha consisted of 400,000 volumes. ( 18) He was the first to doubt the unassailability of Euclidian geometry.

He authored several books, some of which are improved translations of Euclid, Ptolemy and Appolonius. In his book on astronomy *Tadhkira fi ilm al-Haiya* - memoirs on astronomy, he criticized many of Ptolemy's theories and presented his planetary model. This led future astronomers to develop alternative models ending in Copernicus (1473-1543) famous work. He also made original contributions in mathematics, one of which was creation of trigonometry as a mathematics discipline in its own right rather than as a tool for astronomical applications. Another mathematical contribution was his teaching about Chinese triangle ( now called Pascal's ) relating binomial coefficients, long before the time of Pascal.

In his Memoirs he criticised Almajest with regard to anamolies of the moon, motion of the planets in latitude ( notably Mercury & Venus) and proposed a new system. In this he showed considerable ingenuity and obtained oval shaped orbits of the planets. His criticism was step towards the emergence of heliocentric system of Johannes Kepler. ( *Commemorative Volume, page 566, 1971*) . He invented an astronomical instrument called TURQUET that contained two planes.

Tusi's book on mathematics *Figure of the Sector* is noteworthy. He revised the translation made by Sabit ibn Qurra of Archimedes' book The Sphere and the Cylinder which was published from Hyderabad, India in 1940 under the title *Kitab al-Kura wal-Isatawana*. Tusi established that the sum of two squares each of which, is an odd number, cannot be a square. He developed six fundamental formulas for the solution of spherical right-angled triangles.

At his observatory he prepared accurate tables of planetary movements. He published "*Ilkhanid Tables "* , dedicated to Ilkhanid Helagu Khan, after making observations for twelve years. These tables also contain a catalogue of approximately 990 stars. He calculated the value of 51 degree for the precession of equinoxes. He also wrote 'how to use' manuals on instruments, for example on constructing and using an astrolabe. His astronomers perfected the armillary sphere, which consisted of three rings. He had a number of brilliant pupils, one of which was Qutubuddin Sherazi ( 1236-1311) who gave the first mathematical explanation of the rainbow. Another pupil of note was Nizam al-Raj who wrote a commentary on the Almajest. He revised a manuscript titled 'Kitab almutawassitat bainal hindsa wal-Haiyat' which was translated by physician Kosta ibn Luka (864-923) four hundred years ago. As Royal astronomer of Helagu Khan he was able to save many libraries and institutions during the widespread destruction of Baghdad.

Tusi wrote the first systematic treatise *Kitab Shakl al-Qatta* on plane and spherical trigonometry, treating the material as an independent subject and not as handmaid of astronomy. This treatise remained without a rival for nearly two centuries. He observed that a combination of two uniform circular motions in the usual epicyclic construction can produce a reciprocating rectilinear motion. This theorem of Nasiruddin, was rediscovered by Copernicus centuries later. An Orientalist has stated that the kinematic schemes of some planets in Tusi and other Muslim authors remind us of the Copernican theory. (19) . George Sarton has listed 64 books written by Tusi, one quarter of these in mathematics, another fourth in astronomy and the remainder on various subjects written mostly in Arabic.

(25) Qutubudin **al-Shirazi** ( Shiraz 1236-Tabriz 1311) He made his name in optics, astronomy and medicine. At age 14 on his fathers death he became a physician at Muzaffari hospital where his father was employed as physician and ophthalmologist. In 1262 he became formost student of al-Tusi at Maragha. With al-Tusi he studied astronomy and philosophy. For a while he studied at famous Nizamiya college, Baghdad. In Konya he became a disciple of ibn al-Arabi. His love of learning became proverbial in Iran, he was given the title of ALLAMA, rare in medieval times. He was known as a master chess player and of the lute.

His famous works are : *Tahrir Usul Uqlidas* (Recension of Elements of Euclid), *Nihayat al-Idrak (* Limit of Understanding), *Ikhtiyarate Muzaffari* (Muzaffai selections) his masterpiece, *Al-Tuhfa al-Shahiyya fil Haya* ( Royal Gift on Astronomy*), Kitab fil Haya* ( Book on Astronomy), *Kitab al-Tabsira fil Haya ( Commetary* on previous book) , *Sharah al-Tazkira* (Commentary on Tusi's book) *Hall Mushkilat Al-Majisti* ( Solutions of the difficulties of Almajist), *Al-Zij al-Sultani* ( Astronomical Tables).

In medicine he wrote 12 books, of which *Durra al-Taj* ( Pearls of the Crown) is an encyclopedic work. His famous studens were Kamaludin Farsi and Qutub udin al-Razi. He wrote several commentaries on Ibn Sena's books.

He emphasized the relation between the movement of the sun and the planets in the way that prepared the way for Nicolas Copernicus. He was especially interested in the phenomena of rainbow and was the first person to have explained it correctly. He said that rainbow was the result of the passage of light through a transparent medium ( the raindrop). Ray of light is refracted twice and reflected once to cause the observable colors of the primary bow.

25A) **Kamaluddin Farsi** ( died 1320): He was an outstanding authority in mathematics and optics. He wrote a number of works in arithmetic and geometry, his major contribution was in optics. His magnum opus *al-Basair fee ilm al-Manazir* ( Insight into the science of optics) is a textbook for students. He wrote Tanqih al-Manazir, a revision of ibn al-Haisham's book. His study and explanation of rainbow is considered to be the most important work in the field of optics.

(26) **Qazi Zada** (1364- 1436) : He was born in Bursa, Turkey and died in Samarkand, Uzbekistan. He was a professor of mathematics at Samarkand where another notable mathematician Ulugh Beg was a student at his classes. After the death of al-Kashi, he became director of Samakand observatory. He determined the value of the sine of an angle, computing sin 1 degree to an accuracy of 10- 2 ( if expressed in decimals. ) He worked most of his life computing tables.

(27) **Ibn al-Shatir** (1305-1375) : He was the most distinguished astronomer of 14$^{th}$ century. At age ten he traveled to Cairo to study astronomy. He was had muwaqqit at the Ummaya mosque in Damascus. He constructed astrolabes, quadrants, and sundials. His most significant contribution in astronomy was his planetary theory. His theory was investigated in the 1950's and a startling discovery showed that his planetary models were mathematically identical to those of Copernicus. A number of investigations are going on to determine as to how his theory was transmitted to Europe.

His books: *Zij al-Shatir*, *Nihatatul al sul fee Tashih al Usul* ( on planetary theory), *Taliq al-Arsad* (on observations), *Zij al-Jadid* ( handbook with astronomical tables).

On Instruments: Perfect quadrant, sine quadrant, Universal quadrant (Tuhfat al Sami), Risala fee Asturlab fee Usul ilm al-astrulab (principles of astrolabe) fee amal bil astrulab ( on the use of astrolabe) Urjuza fl kawakib , (a poem on stars, Kitab al Jabr wal-Muqabila ( on algebra).

(28) Ghiyasuddin Jamshed Masood **Al-Kashani- or Kashi** ( 1390-1450): He was born in Kashan, Iran and died in Samarkand. Al-Kashi calculated to sixteen decimal places and considered himself the inventor of decimal fractions. He also worked on solutions of systems of equations. He wrote a book *Miftahul Hisab* (Key to Arithmetic) which summarizes arithmetic and contains work on algebra and geometry. In another work al-Kashi applied the method now known as fixed-point iteration to solve a cubic equation having sin 1 degree as a root. He was the greatest mathematician in the field of computation and number theory. He made an axact determination of the value of pi. (20)

Al-Kashi was one of many distinguished astronomers and mathematicians patronized by Sultan Ulugh Beg, grandson of conqueror Timure Lang (Tamarlane). The *Key to Arithmetic* was comprehensive, well-arranged book intended for merchants, surveyors, and astronomers. It exercised a wide influence in the Islamic world. In his numerous mathematical works written in Arabic & Persian, noteworthy is the accuracy of his computations, especially in connection with the solutions of equations by Horner's method. He delighted in long and complex mental calculations.

His other famous books are 1. *Sullam al-Sama* (stairway to heaven ) a treatise on the size and distances of the heavenly bodies. 2. *Mukhtasar dar ilm-I-Haiyat* (compendium of the science of astronomy) a copy preserved at British Museum. 3. *Khaqani Zij* – astronomical tables 4. *Risala dar sharh alati Rasad* ( explanation of treatise on observational instrument 5. *Nuzha al-Hadaiq* (Garden excursion) in which he described 'plate of heaven' an astronomical instrument 6. *Risala al-Muhitiyya* (a treatise on the circumference) 1427 7. *Risala al-Watar wal jaib* (on chords and sines) 8. Translated Ulug Beg's Zij from Persian into Arabic 9. Kitab al-Fusul fil Hisab al-Hindi (treatise on arithmetic) 10. Constructed 8 astronomical instruments.

In Arabic a scientist is called Maulana, but he was called *Maulana-e- Alam*. His relations with 60 other scientists and scholars employed at madrassa, and observatory in Samarkand were amicable, including Qazi Zade.

(29) Muhammad Targhai **Ulugh Beg** (1393 - 24th Oct 1449) : He was a resident of Samarkand. Besides being the ruler of Turkestan, he was an exceptional mathematician and astronomer. He was a HAFIZ, one who had committed the entire Quran to memory. He made Samarkand a leading city of Muslim civilization by building a madrassa ( school of higher learning) and a magnificent observatory in 1428. It was 120 feet high, its diameter 250 feet, circular in shape. The location of this observatory was confirmed by Russian archaeologists in 1908. To see a

reconstructed architectural view of this observatory and a full view of built in quadrant, see page 95 of Fred Hoyle's book *Astronomy*, New York, 1912.
At this observatory the positions of the stars studied by Hipparchus were mapped afresh, these observations being the most accurate of all such made before the time of Tycho Brahe. (21)

Michael Rogers in his book *The Spread of Islam* states " On rising ground of Samakand are the remains of Ulug Beg's observatory. It is described in some detail in great Mogul King Babur's Memoirs.
In 1941 Soviet archaeologists did excavations on the site, and restored its basement plan, 11 meters into thehillside. The excavation revealed a double sextant used for observation of the sun, moon and planets, lodged in a circular building, 48 meters in diameter. The sextant is calibrated in degrees, its angle of curvature gives a radius of 40 meters, which confirms Babur's observation that it was three stories high.

The observatory completed by 1428-29 and the star tables ( ZIJ-I-GURKANI) were completed by 1437. The smaller rooms in the basement housed the library and rooms for the mathematicians employed in calculating the star tables. Some of the larger instruments – astrolabe, armillary, spheres, sundials etc – were used from the roof. " (1976, page 23, Oxford, Uk )

He wrote a book *Zij aljadid Sultani* which was published in English in 1917. George Sarton, famous US historian of science has described this Zij as the greatest masterpiece of observational astronomy in Islam. In 1437 he compiled a star catalogue giving position of 992 stars. His compilation of tables of sines and tangents at one-degree intervals are, accurate to eighth decimal places. With data from his observatory, he computed the length of the year as 365 days, 5 hours, 49 minutes and 15 seconds. To acknowledge Sultan's accomplishments, a surface feature of the moon is named after him, which is an elliptical ring in the NW of Eighteenth Section. Several leading mathematicians /astronomers like al-Kashani and Kazizada worked at this observatory.

(30) Abulhassan ibn ali **Al-Qalasadi** (1412-1486): He was born in Bastah (Spain) and died in Beja (Tunisia). He spent his life in Bastah (now Baza) until Christians captured the city. He then left and traveled through the Islamic world. He wrote several books on arithmetic and one on algebra. He used the method of successive approximation to determine square roots. He also used symbols in algebraic equations.

In his book '*Aljabar wal-Muqabala'* he referred to the two operations used by him in the process of solving linear and quadratic equations.

Before we close this survey, mention must be made of five scholars who made contributions which are of no less significance. Muhammad ibn **Jabir Lebanani** - died in 929 in Baghdad. He made astronomical tables (Zij Lebanani), which was translated into Latin in 1113. He disagreed with trepidation of equinoxes. He measured inclination of ecliptic to be 23 degrees and 35 minutes. He believed that earth's obit around the Sun was not circular but elliptic. Abul Qasim **al-Majriti** - died in 1007 in Cordoba. He introduced mathematics and chemistry into Islamic Spain. In Cordoba he founded a university where such luminaries as ibn Khaldun and al-Zahrawi studied. He wrote books on mathematics, chemistry & edited and corrected al-Khowrzimi's Tables. His recension had a trigonometric supplement in which the term JAYB (pocket) was used and was translated into SINE thus adding a new technical word to European languages. In chemistry he wrote two books *Rutabatul Hakim* (*The Sage's Aim) and Ghayatul Hakim (The Aim of the Wise-* Latin Picatrix) which became a mainstay of chemistry literature in Europe.

A copy of this book is available at Library of Congress, published from Spain in 1982. He also wrote a book on commercial arithmetic, *al-Muamailat* . Abul Hassan **al-Uqlidisi** - was a tenth century mathematician who lived in Damascus. Decimal fractions first appeared as a stroke above the number in his book *Kitabul Fasus*. Bahauddin **al-Amili** (1547-1622) was a Persian from Isphahan. He wrote a book Essence of Arithmetic (*Khulasa al-Hisab*) which stands about the same level as work of al-Khowrzimi. He devised an approximate law to find the square roots of 'deaf' numbers. He was the last religious scholar who was a renowned mathematician. He was the last figure of learning in the Muslim world, after him teaching of mathematics was ignored in schools His book in astronomy is *Tashreeu*l *Aflak***.** **Ibrahim al-Zarqali** (1020-1087) of Toledo, Spain made an international name by improving astronomical instruments, Copernicus quoted his treatise on the astrolabe, his astronomical observations were the best of his age, and enabled him for the first time the motion of solar apogee with reference to the stars; his TOLEDAN TABLES of planetary movements were used through Europe . (Age of faith, p305)

*suwar al-buruj*

The signs of the Zodiac. These are twelve, viz. (1) *hamal* (ram); (2) *thaur* (bull); (3) *jauza'* (twins); (4) *sartan* (crab); (5) *asad* (lion); (6) *sunbulah* (virgin, lit. "ear of corn."); (7) *mizan* (balance); (8) 'aqrab (Scorpion); (9) *qaus* (archer); (10) *Jadi* (goat); (11) *dalw* (bucket); and (12) *hut* (fish). See also *mintaqat al-buruj*.

### Minaret as observatory

In 1081 Ibrahim **al-Sahdi** of Valencia, Spain constructed the oldest celestial globe, a brass sphere 81.5" in diameter; upon its surface in 47 constellations, were engraved 1015 stars in their magnitude.

The *Giralda of Seville* (1190) was an observatory as well as a 300 feet high minaret of the grand mosque of Seville where **Jabir Ibn Aflah** made the observations for his book *Islah al-Majisti* in 1240. There was a ramp in the minaret wide enough to make the ascent on a horseback. It was also the most impressive example of architecture in Spain. It's now a belfry and still dominates the city of Seville. ( *The Moorish Spain by Jan Read, page 165, 1975*) . Works of Abu Ishaq **al-Bitruji** of Cordoba, paved the way for Copernicus by criticizing the theory of epicycles and eccentrics through which Ptolemy had sought to explain the motions of the stars.

(31) Professor **Abdus Salam** ( 26 Jan 1926 - 29 Nov 1996) : He was born in Jhang, passed away in Oxford and was laid to rest in Rabwah, Pakistan. The only Muslim to win a Nobel prize in science was a brilliant mathematician. At age 17 he solved a problem of Ramanujan, named after Indian mathematician Srinivasan Ramanujan (d1920). He obtained double first (Wrangler) in mathematics from Cambridge University. He was appointed professor of mathematics at Government College, Lahore and later at London University. In 1951 he wrote an epoch-making paper on Renormalization theory ( a mathematical technique) which brought him instant recognition from the scientific community.

He founded the International Centre for Theoretical Physics in Italy in 1964. The Centre has imparted training and research experience to more than 38000 scientists. It has received 8500 high level physicist and mathematicians for post doctoral experience. During his illustrious career as an educator, he produced more than 50 Ph.D's and one Nobel prize winner. He wrote 276 research papers.( 22) He was an indefatigable scholar, educator, theorist, philanthropist, and a visionary. His books include Ideals & Realities, Unification of Fundamental Forces, Aspects of Quantum Theory.

### Summary

The achievements of Muslim mathematicians can be summarized as follows: 1. they developed number theory in its mathematical aspects. 2) devised new methods of numerical computation 3) dealt with decimal fractions and numerical series. 4) developed and systematized the science of algebra 5) developed trigonometry, both plane and solid 6) made trigonometry an independent science.

**References:**


1. Holy Quran, 4: 12, 13. Fractions are mentioned in these verses.
2. History of Medicine by Prof. Neuberger, page 349, 1910
3. Abdus Salam by Dr. A. Ghani, page 105, , 1982, Karachi
4. History of Medicine, page 350
5. Musalaman Sciencedan (Urdu) by I.A. Nadvi, page 37. 1993, New Dehli
6. Capital Cities of Islam, by P.K. Hitti, page 98
7. Sirguzishte Falsafa (Urdu) by Dr. N.A. Nasir, page 186 , 1991, Lahore (contains complete list of al- Kindi's books)
8. Legacy of Islam, by J. Schacht, page 479, 1974
9. History of mathematics by W.W. Ball, 1912. NY
10. Outline of Islamic Culture by A.M. Shushtry, page 118, Lahore
11. American Encyclopedia, vol 33, page 224, 1988
12. Age of Faith by Will Durant, page 244, 1950
13. Legacy of Islam, page 476
14. Al-Biruni Comemmorative Volume, page 622, by Hakeem M. Saeed, Karachi 1979
15. Review of Religions, article Bu Ali Sena, Dec 1991
16. Medieval Medicine, by B.L. Gordon, page 6, 1959, NY
17. Hist of Science by G. Sarton, page 956, 1927 USA
18. Hukamai Islam (Urdu) by A.Salam Nadvi, page 257, 1956, Hyderabad, India
19. Legacy of Islam, page 480

20. Science & Civilization in Islam by S.H. Nasr, page 151, 1968
21. History of Sciences by Mason, page 77, 1953, NY
22. Abdus Salam - as we know him by S. Ahmad, 1992, Karachi. This book contains a complete list of 276 research papers with file numbers.

Suggested Reading: Alhazen's Billiard Problem in 100 Great Problems of Elementary Mathematics, By H. Dorrie,, New York, 1965

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Chapter 4

# Golden Age of Islamic Medicine

*We Shall show them our portents on the horizons, and within themselves, until it will be manifest unto them that it is the Truth. ( Glorious Quran, chapter Al-Shura 41:53)*

When Abbasid Caliph al-Mansoor (754-775) the second ruler of Baghdad fell sick and his physician could not cure him, he sent for a Persian physician from the medical academy of Jundi Shapur, Iran. Thereafter the Caliph began to favor physicians and patronize medicine.

The golden age of Islamic medicine lasted from eighth to thirteenth century when skilled Muslim physicians were produced. These physicians did not merely present old medical theories and cures, they were outstanding scholars and medical practitioners of the highest order during the middle ages.
Some of them were given the honorific titles of Arabic Galen, Prince of Physicians, or Eagle of Doctors. The most famous of these were al-Tabari, al-Razi, Ali ibn al-Abbas, Ibn Sena, al-Zahrawi, al-Tilmiz, ibn Zuhr, al-Jurjani, Ibn Rushd, al-Samarqandi, Abdul Lateef, Ibn al-Quff, and Ibn Nafees. This survey covers their achievements, medical instruments they devised, new ideas they presented and their literary contribution to the science of medicine which immensely influenced later generations.

Books authored by these scholars were fundamental to the development of surgery and medicine in Europe during the renaissance. Throughout the length and breadth of Islamic Empire, Muslim rulers and rich people promoted *book culture*. Books were regarded as gems of rare beauty. There were one hundred booksellers in Baghdad in the ninth century, the city also housed 36 public libraries. Having private libraries was a favorite hobby for the rich people, big mansions contained five to ten thousand books.
One physician claimed that his library would require 400 camels to move it. Another one left 600 boxes of books when he passed away. Caliph al-Hakam II had 400,000 books in his Cordoban library.

**Al-Tabari ( 775-875)**

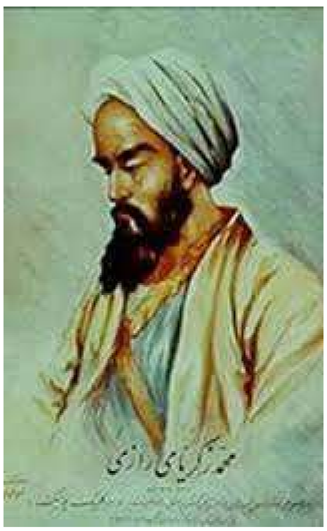
Abul Hassan Ali Bin Raban al-Tabari, was born in Tabaristan, moved to Rai where he practiced medicine for a while. He received education from his father who taught him arithmetic, medicine, philosophy, and several languages including Arabic, Hebrew, and Greek. For a while he was secretary to the governor of Tabraristan. According to Fihrist of al-Nadim, he composed 16 treatises on medicine. A manuscript of *Hifzu Sihat* is at Bodleian library in Oxford.

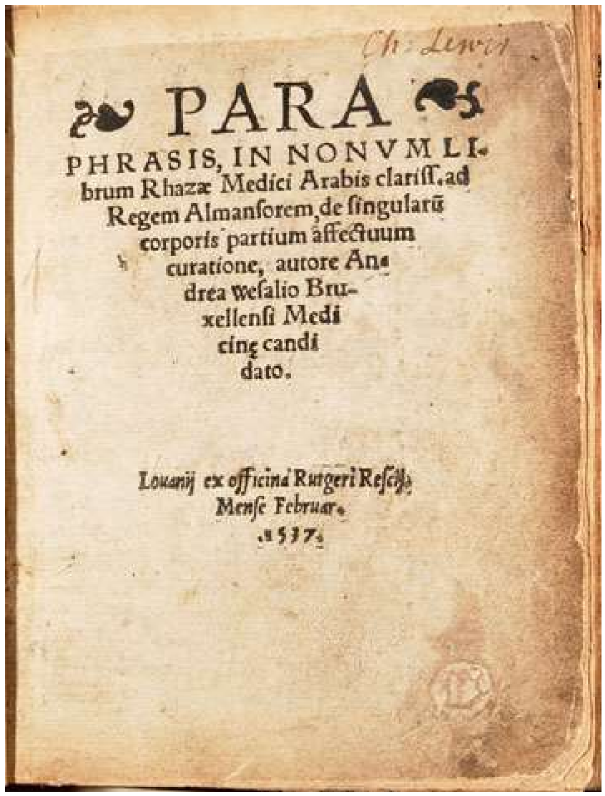
After moving to Baghdad he acquired an extensive practice. He was boon companion and court physician of Caliph al-Mutawakil (847-869). His major medical work is *Firdaus al-Hikma* that was completed in 850. It deals with embryology, hygiene, and virtues of food, zoology, psychology, astronomy, and meteorology. He was one of the teachers of al-Razi. George Sarton is of the view that he made the first translation of Almagest. (1)

Copies of his medical compendium are at British Museum (Arundel Or41), Rampur, Aya Sofia Istanbul, Danish Gah Tehran, and Berlin. It has 550 pages, 30 discourses, and 360 chapters. Signs and symptoms of each disease are given, treatment recommended for each. There are clinical notes. It is the earliest extant medical book written in Arabic. (2) Dr. Zubair Siddiqui published an Arabic edition from Berlin, while Hakim Rashid Ashraf Nadvi, Karachi, made an Urdu translation in 1980. (3)

**Al-Razi ( 854-935)**

Muhammad ibn Zakariya al-Razi was born in the city of Ray located not too far from modern Tehran. He got interested in medicine when he was over forty years old. Ibn Juljul (944-994), the famous physician-historian from Islamic Spain says, " in his youth he played on the lute and cultivated vocal music, but on reaching the age of manhood, he renounced the occupation."





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One day while visiting the sick houses of Baghdad he was touched by the misery of the sick. After leaving the hospital he resolved to devote the rest of his life to medicine. In Baghdad he acquired medical training from renowned teachers, like famous al-Tabari, author of a medical encyclopedia *Firdaus al-Hikma*. He became an expert physician in a short span of time, hence he was appointed director of the hospital in his native Ray, and later on at the Adudi hospital of Baghdad by Caliph al-Muqtadir. He commanded high fees from the rich, but lived in poverty to help the poor patients. To further his knowledge of medicine he visited Palestine, Egypt and Spain.

In Spain while passing through the streets of Cordoba, he saw a crowd collected around the body of a man who was said to have just fallen dead. He caused him to be beaten all over with rods, and particularly on the sole of his feet, by which means in less than a quarter of an hour, he restored him to animation. Upon being questioned about this singular remedy, he said that he had seen it used with success in a similar case by an old Arab; and added "experience is of more use than a physician". (4)


al-Razi statute

As he was thoroughly grounded in the principles of medicine, and skilled in its practice, students traveled from distant countries to receive training from him. When he visited the hospital his pupils and pupils of his pupils surrounded him. Pupil's pupils first examined every patient, if the case was difficult to treat, it was passed to his immediate pupils, and finally Razi treated the hard cases. His students considered him second Galen. When he was asked to select the most suitable place for the construction of a hospital in Baghdad, he hung meat in various corners of the city, chose the place where it had shown no sign of decomposition. His admirable power of observational power, his sharp intellect and encyclopedic knowledge earned him the title of Arabic Galen. He was a master of prognosis and psychosomatic medicine.

Razi was one of the great epoch makers in the history of medicine. He presented opinions of ancient medical authorities first, then his own experience under the heading *'My Opinion*". In his treatment of disease he relied heavily on diagnosis and prognosis. His contemporaries called him "The Experienced". Cyril Elgood is of the opinion that "Medicine was born: Hippocrates created it. It was dead: Galen revived it. It was scattered: Rhazes re-assembled it. It was imperfect: Avicenna perfected it. ( 5)

Besides his busy practice Al-Razi wrote many books and manuals in medicine which are characterized for their originality. He was constantly writing, in one year he wrote more than 20,000 pages "in a hand like an amulet maker's". (6) He wrote close to 200 books, half of them on medicine. He practiced medicine for more than 35 years. Some of these works are short treatises like *Birral Saat* (Recovery in One hour, like headache, dysentery), but some are voluminous like al-Hawi in 20 volumes, while al-Mansuri is in ten volumes. Al-Hawi was so popular in Europe that it was one of the nine works, which made up the library of Faculty of Medicine in Paris in 1395.

He was an outstanding diagnostician, clinician, and therapeutist. He wrote on a variety of subjects like ophthalmology, obstetrics, and gynecology. His treatise on the diseases of children was the first known treatise on pediatrics. He used psychotherapy with dramatic results, antedating Sigmund Freud by a thousand years.

Prof Max Neuberger has summed his character in these words: " *Rhazes was a man of rare attainment, who linked the knowledge of his age to the achievements of the past, a tireless writer of immense productiveness and versatility, an inspired teacher. As a clinician he stands high above all Arabic, possibly above all medieval physicians. He set greater value upon description of disease than upon theoretical speculation; his works contain numerous clinical histories, which are proof of his powers of observation. He expended great care upon diagnosis, and prognosis. He was guided by independent experience, not only in his clinical descriptions, but also in therapeutics, wherein he experimented with chemical preparations. His gigantic magnum opus al-Haw represents the fruit of a long life spent in untiring labor. "* ***( 7)***

Razi was a prolific writer, though Persian by birth, he composed his works in Arabic, then scientific language of the world. Al-Biruni prepared a complete list of his 187 works. In German a catalogue of his works is in Wustenfeld's *Geschichte der Arabischen Aertze und Naturforscher,* while Page 140 and 141 of the English translation of al-Jadari wal-Hasba by Greenhill, contains a list of 37 medical treatises translated into Latin.

**Kitab al-Hawi Feel al-Tibb -** Comprehensive Book on Medicine**:** This book was compiled from his medical notebook consisting of thousands of pages. His sister sold these notes after his death. His students published these unfinished notes after careful editing. The work is an undigested mass, without order or arrangement because it was never intended for publication. It was a daunting task for scribes to copy the entire manuscript; hence only two original manuscripts are preserved. Ali Ibn Abbas, who lived 50 years after Razi, said that he had heard of only two complete copies. (Kitab al-Maliki, Cairo 1877, vol I, pages 5-6) It is considered to be one of the most valuable medical books of antiquity.

colophon of kitab al-Hawi

Al-Hawi is divided into 25 books. Because of its size it exists in volumes only in European libraries. I had the pleasure of reading the Arabic volume in Bodleian Library, Oxford (Marsh-156) in July 1999. The title page reads in Arabic - *Al-Hawi fil Tibb, Mujallid alHawi alKabir Muhammad bin Zakaria al-Razi*. This is the 7th volume of al-Hawi. There are some volumes in British Museum, and Escorial library, Madrid. Last year I traveled to Escorial to see this manuscript, but the library was closed due to summer holidays. The book is organized anatomically from head to toe. It was first translated into Latin under the title Liber Continens, by Faraj ben Salim in 1279 for King Charles of Anjou. It was printed in 1486 in Latin and many times thereafter 1486, 1500, 1506, 1509, 1511, and 1542. The Arabic text in 12 volumes was printed in 1955 from Hyderabad, India.

Dr. Koning published the anatomical section of al-Hawi, along with anatomical sections of al-Qanun of Ibn Sena and Kitab al-Maliki of Ali Ibn al-Abbas.

National Library of Medicine, Maryland, USA has part of the original treatise of al-Hawi on gastro-intestinal complaints. It is the oldest volume in NLM, the 3rd oldest manuscript known to exist, written by an unnamed scribe in Baghdad, dated 30th November 1094. (MS. A 17)

**Kitab al-Judri wal-Hasba**: This book brought glory to al-Razi for this was the first treatise that differentiate the two diseases, smallpox and measles. No one is sure of the exact date of its composition. It was translated from original Arabic into Syriac and then into Greek. The Greek translation was made at the request of Constantine Dukas, Emperor of Constantinople. Mead translated it from Arabic into Latin in 1747. It has been translated 12 times into Latin. It was published in English and Arabic in London in 1766. First Latin translation was printed in Venice in 1565 entitled *"Liber de Pestelentia*". Professor Neuberger has stated that "on every hand and with justice it is regarded as an ornament to Arabian medicine" (8) I have studied the English translation of this treatise, published in 1848 from London, and preserved at the Health Sciences Library, Queen's University, Kingston, Canada. In the history of medicine his fame rests on this treatise. It was the earliest monograph in the history of epidemiology.

Karl Opitz translated it into German, entitled Uber die Pocken Und die Masern, printed at Leipzig in 1911. There are two Arabic manuscripts of this treatise, one in University of Leyden (Holland), and the other at Codices Naniani at Venice. Greenhill's English edition gives a complete list of 35 translations printed in various European cities in a span of 350 years. " A greater number of editions than has been fallen to the lot of almost any other ancient medical treatise." The treatise is divided into 14 chapters; page 137 gives a brief sketch of his life.

**Kitab al-Mansoori** : This book consists of ten volumes. It was translated into Latin as *Liber ad Almansorem*. It was dedicated to ruler of Khurasan, King Mansur ibn Ishaq, hence its title. On completion of this work, the King awarded him one thousand dinars. The book contains many of his original ideas. During the Middle Ages he was considered the greatest medical authority, some regarded him second only to Hippocrates. The ninth book of Latin version - On diseases from head down to the feet - was a popular textbook in the Middle Ages. It was publicly read in schools and commented upon by most learned professors.

Manuscripts of this book are to be found in Madrid (Escorial), Dresden, and at Bodleian (Marsh 248), printed in 1481, 1494, 1497, 1500, 1510, and 1544. Gerard of Cremona translated it into Latin. It consists of ten books 1. anatomy & physiology, 2. Temperaments 3. Foods & simple medicine 4. Means of preserving health 5 Skin disease and cosmetics 6. Diet of a person on journey 7. Surgical section 8. On poisons 9. Treatment of disease of all body parts 10. Fevers. (9)

His Kitab al-Jami al-Kabir (Great Medical Compendium) was published during his lifetime. Mansuscripts of his treatises on gout and rheumatism and colic are preserved in Cambridge University library (Add 3516). He also authored several other works in medicine like Jami (Compendium), Kafi (Sufficient), Muluki (Royal), Fakhir (Splendid), Madkhal (Introduction), Stones in Kidney & Bladder,
Kitab al-Murshid, Tibbe al-Ruhani (Psychological medicine). In the last work he stated that all pleasures presuppose a prior pain. This means that lack of anxiety or pain is the optimum of pleasure (10)

His achievements: Many things are credited to him for inventing, or for using for the first time. For instance he used sutures of animals gut for abdominal wounds (he used harp strings), he introduced several remedies in therapeutics, notably mercury ointment, he discovered sulfuric acid which he distilled from iron sulfate, he distilled alcohol from starchy and sugary matter, he described the recurrent laryngeal nerve in one of his treatises on anatomy, he was the first to describe that form of osteitis which later became known as spina ventosa, he was the first to write a monograph on the diseases of children, he put forth the idea of a process of fermentation in the blood as a cause for infectious diseases. He discovered the use of alcohol as antiseptic. He was the first to describe the presence of sour matter in the stomach, a fact confirmed by our understanding of the digestive system. He prepared the sulfides of copper and iron and thus added a new chapter of inorganic compounds now used in medicine. He made medical use of mercury as purgative (after testing this on monkeys), this drug was called Album Rhazes during the middle ages. He was the first physician to find stones in the bladder.

He was the first to apply chemistry to the treatment of disease. He made experiments on the specific gravity by means of hydrostatic balance. His treatise on chemistry contains 25 pieces of chemical apparatus he used in his lab. He was acquainted with many drugs like camphor, cardamom, musk, manna, amber, nutmeg, and alcoholic drinks.

In order to see effects of mercury on humans, he experimented first on animals. This is how he described this in Kitab al-Masuri; " *I don't suppose that any great harm would happen to a man who should drink mercury, except some severe pains in the stomach and intestines. I gave some to an ape that I had, nor did I see any evil befall him beyond that above mentioned, which I concluded from the fact that he twisted about and kept biting at his stomach and pawing it with his hands. (* Book 8, page 42)

Following anecdote shows his excellent diagnostic acumen. Abdullah ibn Sawda used to suffer from attacks of mixed fever, sometime quotidian, sometimes tertian, sometimes quartan, and sometimes recurring once in six days. These attacks were preceded by a slight rigor, and micturition was frequent. I
gave it as my opinion that either these accesses of fever would turn into a quartan, or else there was ulceration of the kidneys. Only a short while elapsed ere the patient passed puss in the urine. I informed him that these feverish attacks would not recur, and so it was. (11)

His keen sense of observation is further displayed in the following extract from his treatise on Smallpox. " I have found upon examination that the amount of danger in the small-pox be estimated by the difficulty of breathing and hoarseness of voice, and that many persons die of suffocation, and, therefore I think you should begin at once with taking care of the throat, at the commencement of the attack with styptic remedies, towards the end with lenitive and laxatives. In the hospital I have found that in the

Smallpox and Measles you should use bloodletting before the fourth day and after it, and especially before all the symptoms appear. ( 12)

It is also said that he treated a patient suffering from paralysis of his legs by suddenly threatening the patient with a knife as if intending to kill him. The shock made the patient spring to his feet and paralysis was cured. ( 13)

In ophthalmology he wrote a treatise "On the Nature of Vision" and said that eyes are not the mediators of light. In al-Hawi he recorded many of his own observations. He was the first to describe headache as a symptom of weak eyes. In Volume 2 of al-Hawi there is a detailed note on glaucoma. He also suggested that two things could cause weakness in the eyes, over consumption of salt, and over indulgence in sex. In this he was referring to hypertensive retinopathy. He was the first to record an account of a cataract operation. Also he described the contraction of pupils to light. ( 14) He wrote several works on this topic like Kitab fee Hayat al-Ain, Kaifiat al-Absar, Maqala fee Elaj al-Ain bil Hadid

In a church at Princeton University, New Jersey, USA is painted a portrait of Razi on the stained window glass as a tribute to this great doctor. I have a computer generated, three feet long picture of this portrait, showing Razi holding his book al-Hawi, the name written in Arabic.

In his old age he became blind due to cataract. This traumatic blindness was caused by the constant blows on the head he received on the orders of King al-Mansur, who became angry at Razi due to his failure to transform a base metal into pure gold. He was beaten on the head with his own book Al-Mansuri, until either one or the other had broken. (15) At first he was inclined to have the operation performed on him, but when he asked the surgeon to tell him how many membranes the eye contained, the surgeon expressed his ignorance. Razi refused to be treated and said, " I have seen so much of the world that I am weary of it." He died at an advanced age in abject poverty having distributed his wealth to the poor.

**His aphorisms**

1. When you can cure by regimen, avoid having recourse to medicine, and when you can effect a cure by means of a simple medicine; avoid employing a compound one.
2. With a learned physician and an obedient patient, sickness soon disappears.
3. Truth and certainty in medicine is an aim which is not to be attained; and the healing art, described in books, is far inferior to the practical experience of a skillful and thoughtful physician.
4. Then you can heal by diet, prescribe no other remedy, and where simple remedies suffice, do not take complicated ones.
5. Physicians ought to console their patients even if the signs of impending death seem to be present
6. In treating a patient, let your first thought be to strengthen his natural vitality.
7. It is good for the physician that he should be able to cure disease by means of diet, if possible, rather than by means of medicine.
8. A patient, who consults great many physicians, is likely to have a very confused state of mind. **(16)**

The famous Italian/Spanish translator Gerard of Cremona translated following works of Razi into Latin. 1) Antidotorium - the original Arabic works is Aqrabadin al-Kabir, dealing with the removal of harmful effects of simple and compound drugs, poisons of animal, plants or mineral origin and foods.
2) Liber Almansorium - this was shorter version of his great medical compendium. 3) Liber Divisionum - the Arabic original is Kitab Taqsim al-Ilal, consisting of 154 chapters. 4) Liber Introductorius in Medicinum Parvus - the Arabic original is Kitab al-Mudkhal Ila Tibb. 5) Experimenta Rasis - the Arabic original is *Kitab al-Tajarib* 6) Aphorismi Rasis - this book is in 37 chapters, containing over 300 aphorisms. The Arabic original is Kitab al-Murshid, printed from Cairo in Arabic in 1961 by Z. Iskander. (17)

**Pain and Pleasure**

In his book *al-Tibb al-Ruhani*, Razi considered it a person's duty to avoid grief, because it was harmful for both soul and body. When an intelligent man is met with a calamity he should not allow himself to be over-whelmed with grief. Though he could not be totally free of grief, but if he trained himself to resort to reason, he should be able to return to his normal balanced state of mind. The reasonable thing he could do was to try to forget the grief, by diverting his thoughts from his loss and occupying his mind with other things.

Razi said that the ideal life was to have a life free of deep emotional ties, though it was natural to have these ties, to possess loved ones. Because most men could not live without loved ones, they should prepare themselves for their loss. A man should constantly remind himself that everything; also his loved ones will perish. By picturing to himself frequently the future loss, he would discipline and strengthen his soul, so that when the misfortune does occur, he would be prepared and not fee the pain.

He also said that grief was best avoided by not becoming attached to someone. As the substance out of which sorrows are generated is simply and solely the loss of one's loved ones, and since it is impossible that these loved ones should not be lost because men have their turns with them and by reason of the fact that they are subject to the succession of generation and corruption, it follows that the man most severely afflicted by grief must be him who has the greatest number of loved ones and whose love is the most ardent, while man least affected by grief is he whose circumstances are the reverse.

It would therefore seem that the intelligent man ought to cut away from himself the substance of grief, by making himself independent of the things whose loss involves him in grief; and that he should not be deceived, and deluded by the sweetness they impart while they remain in being, but rather keep in mind and image the bitterness that must be tasted when they are lost. ( 18)

David Riesman has given a list of medical textbooks that were used in the library of the Faculty of Medicine in Paris, between the years 1395- 1516. **Albucasis** (Abul Qasim al-Zahrawi) - Antidotarious, **Avenzoar (**Ibn Zuhr) - Liber Theisir, **Averroes** (Ibn Rushd) several copies of Colliget, **Avicenna** ( Ibn Sena) several copies of Canonis libri, **Mesue (**Ibn Masaweh) - De Simplicibus Medicinis, **Rhazes** ( al-Razi) Totum Continens. ( 19)

**Ali ibn al-Abbas al-Majusi (d994)**

He was a native of Ahwaz, Persia. He received his medical education at the world famous medical school of Jundishapur. He was a court physician of Buwide ruler Adudu Dawla (d983), who founded the Adudi Hospital in Baghdad. His Latinized was Haly Abbas.

Bishop Stephen of Antioch translated his masterpiece in medicine Kamil al-Sinnah al-Tibbiya, or al-Maliki (Royal Book) into Latin as Liber Regius in 1127. It consists of 20 treatises, ten on theoretical principles and ten on practical aspects. The material is well organized, giving lucid description of diseases. It was a standard medical textbook of Arabic medicine for 100 years until it was replaced by al-Qanun. The second and third chapter deals with anatomy, while the 19th is on surgery. Liber Regius was printed at Venice in 1492 and at Lyons in 1523. Many copies exist in several European universities. A manuscript dated 15th May 1208 by a Christian scribe Yousuf ibn Sarkis is preserved at National Library of Medicine, Bethesda, Maryland, USA. (MS A26.1) It was the first book to be printed in Arabic from Cairo in 1877, comprising of 400,000 words, divided into 20 maqalas (discourses) first ten dealing with theory, the later ten with practice.

Prof Neuberger states that al-Maliki " *is distinguished by lucid, systematic description and gives a complete picture of contemporary knowledge. He had upon occasion the courage to forsake authority, and formulate independent opinions. He was emphatic in his recommendations to young physicians to frequent the hospitals for instruction." ( 20)*

He said that there was no substitute for clinical experience, he advised new doctors to spend time in hospitals. He was the first to suggest the existence of blood capillary system. He gave an accurate description of Pleurisy. In describing arteries and veins he spoke of their divisions into numerous lubes spread like hairs, and their connection through tiny pores. He described the relationship between psychology and medicine. Emotional reactions may cause sickness or promote good health, depending on how they are controlled. He also spoke of passionate love. In embryology he explained the currently accepted fact that fetus is pushed out in parturition. He gave the effects of the use of opiates, which can be applied to current drug addiction. He promoted chemotherapy just al-Razi had done before. He promoted health measures to preserve normal condition of body and mind such as diet, rest, bathing, and physical exercise. (21)

In Kitab al-Maliki the chapter dealing with vital functions explains the two opposite movements of expansion (*Inbisa*t) and contraction (*Inqibaz)* which in the heart and arteries constitute diastole and systole, and in the respiratory organs inspiration and expiration. Following paragraph gives a rudimentary conception of the capillary system.

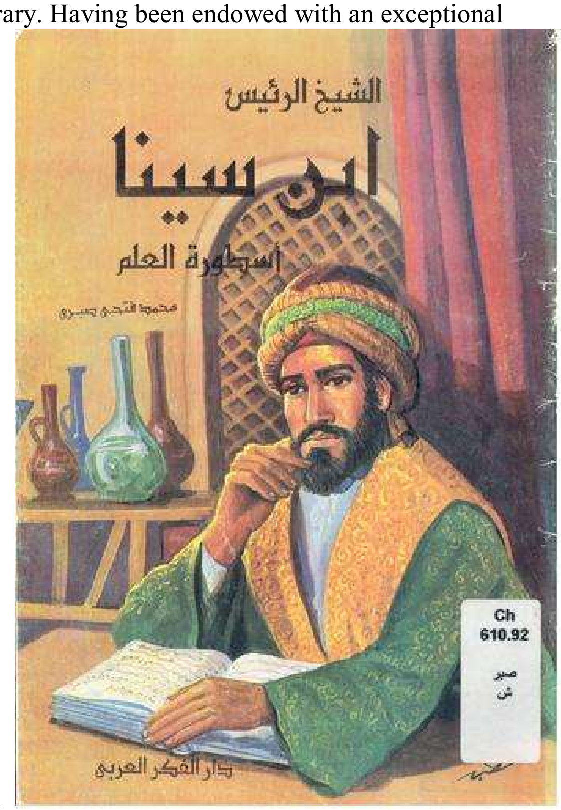
"*And you must know that during the diastole such of the pulsating vessels (the arteries) as are near the heart draw in air and sublimated blood from the heart by compulsion of vacuum, because during the systole they are emptied of blood and air, but, during the diastole the blood and air return & fill them. Such of them as are near the* *skin draw air from the outer atmosphere; while such as are intermediate in position between the heart and the skin have the property of drawing from non-pulsating vessels ( the*



*veins) the finest and most subtle of the blood. This is because the non-pulsating vessels (the veins) are pores communicating with the pulsating vessels (the arteries). The proof of this is that when an artery is cut, all the blood, which is in the veins, is also evacuated. ( 22)*

**Ibn Sena (980-1037)**

Abu Ali Husain Ibn Sena was born in Afshana near Bokhara in central Asia. He was a prodigy who learned mathematics from a green grocer, memorized the Holy Quran at age 10, learned the art of healing at 16 from leading teachers and by 18 he was already an experienced physician. He read Aristotle's *Metaphysics* for forty times until the words were printed in his memory. In 997 as a budding physician he treated Samanid ruler Nooh ibn Mansoor, from a dangerous sickness, thereby earning the privilege to have access to his Royal library filled with unique and rare books. He gobbled up the contents of the books in this library. Having been endowed with an exceptional

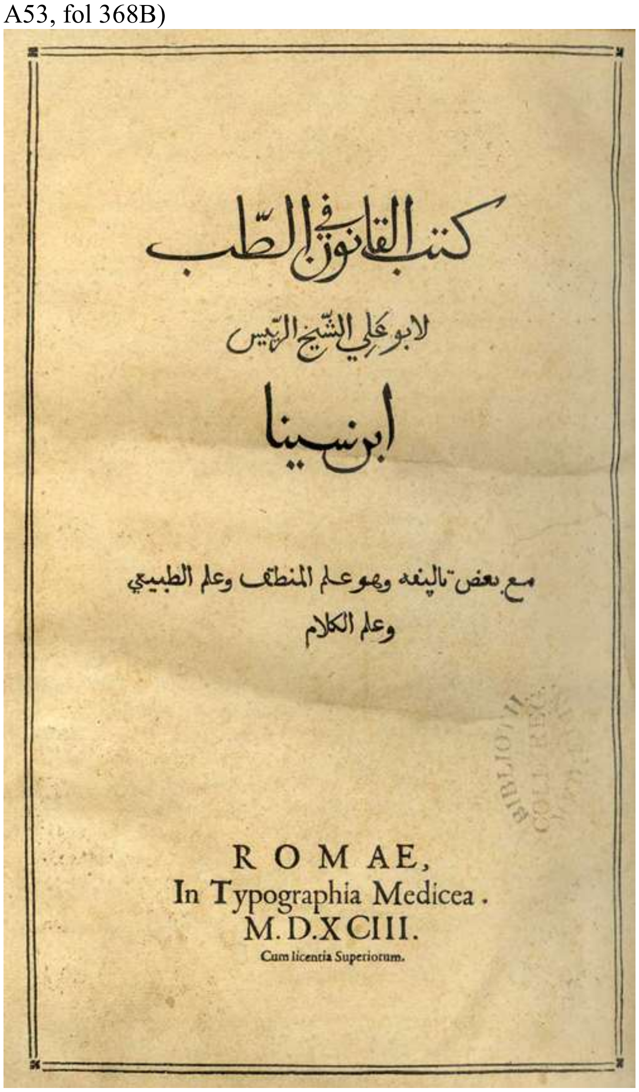



memory, everything he read stayed with him for years to come.

He led a turbulent life, became Prime Minister of ruler of Hamadan, and even went to prison. He composed poetry, wrote on mathematics, physics, mineralogy, chemistry and medicine. He had good grasp of theological issues. He wrote 100 medical works, some few pages long to some consisting of many volumes. He wrote mostly in Arabic. He was an outstanding poet, writing poems in Arabic and Persian.
His poem on medicine in Arabic language is considered a classical beauty, memorized by Hakims in the Islamic countries even today.

His masterpiece in medicine is *al-Qanun feel Tibb*, which he started composing while he was in Jurgan, near the Caspian. He busied himself with state affairs during the day, but at night he lectured and dictated books. Extracts from al-Qanun were explained to students every evening, while night was spent in total enjoyment with singers. The last ten years of his life he was scientific advisor to Emir Abu Jafar Ali Abdullah. He had amazing powers of concentration, dictating books while riding on a horseback during the war. His method was unique; he brought together the theories of his predecessors and presented them in a new form. He was a specialist in colic treatment, but could not cure himself of this ailment. At his deathbed he was remorseful, listened to the recitation of Quran and died in June 1037 at age 58. His tomb in Hamadan is still visited by millions of visitors the world over.

Al-Qanun opens thus: *Medicine is a science from which one learns the state of the human body with respect to what is healthy, and what is not, in order to preserve good health when it exists and restore it when it is lacking.* It consists of five books: first and second deal with physiology & hygienic, third and fourth with methods of treating disease and a treatise on surgery, fifth with materia medica and was the universally accepted textbook up to the Renaissance. In the second book numerous medicaments are listed that were not known before. Third book contains an account of pleurisy, jaundice, ulcer, and venereal diseases. There are personal observations in the last section. It was used as a textbook for 500 years in European medical schools of Montpellier, Salerno, Bologna, and Paris. It was used in Louvain until 1650 while in Islamic countries it is still studied and regarded as a medical authority. It was translated into Latin, by Gerard of Cremona; thirty editions have appeared based on the original. Nathan Amathi rendered it into Hebrew, in 1491, & a Latin edition was printed in Rome in 1593. Famous Spanish physician Musa ibn Maimoon also translated it into Hebrew. National Library of Medicine has a complete copy of al-Qanun
made in Iran at the beginning of the 15th century, with illuminated headings opening each of the five books.(MS. A53, fol 368B)



Kitab al-Qanoon fil Tibb

Al-Qanun was used as a textbook longer than any other book in the history of medicine. No other medical textbook has been so thoroughly studied as this. European writers were much impressed with his high stature, so much so they called him *Prince of Physicians*. In Islamic countries he is referred to as *Shaikh ar-Rais* ( Leader of the

Learned) or *al-Muallimu Sani* ( Second Teacher). Prof. Max Neuberger has beautifully sketched the eventful life of this Muslim giant in the following paragraph. " (He*) was the most perfect embodiment of the essential characteristic of Arabian medicine - the assimilation of vicarious experience and the systematization of empirical knowledge. His monumental figure stands out at the end of the tenth century, serving as an example and guide for a space of five hundred years. Ibn Sena's magnum opus al-Kanun overshadowed the Hawi of Rhazes, the Kingly Book of Ali Abbas, almost even the Galenic writings, depended chiefly upon points of form, the sparkling, lucid diction, the exemplary, comprehensive, profound yet always clear arrangement & the logical sequence. " ( 23)*

His major contributions

He was the first to describe a parasitic infestation by guinea worms. He first recorded the sweet taste of urine of diabetic patients. He introduced the coating of silver and gold on the pills. He was the first to suggest use of water in typhoid. (p 81) He introduced new methods of curing eye-disease. Among them probing of the lacrimal fistule and syringing the lacrimal sac stand out. ( 24) He was the first to suggest that the first step in the digestive system is the mixing of food with the salivary secretion of mouth. He was the first to describe the preparation & properties of sulfuric acid and alcohol. He discovered the antiseptic nature of alcohol.

In surgery he described operations of intubation of the larynx, the technique of tracheotomy and the operation of the empyema with a knife. He talked about deformities of the spinal cord, outlined a treatment for hernia, and operation for lithotomy. He described the manner of opening the vein and the amount of blood that should be withdrawn.

His observations on the nature of germs, is the first Muslim contribution in the field of micro-organism. He was the first to state that foreign earthly body prior to infections contaminates secretion of the body. ( 25) He discovered and described the insertions of the intrinsic muscles of the eye. He suggested that certain disease were water borne, the cause being minute animals that live in the water, too small to be viewed by the human eye. He was the first to attempt to differentiate between obstructive and hemolytic jaundice. In surgery he suggested that the bristles of a pig should be used for sutures instead of linen thread, as they are less likely to putrefy. He suggested that the cause for disease might be the inhaled air. At certain times the air becomes infected and anyone breathing the bad air falls sick. In this he proposed the existence of microbes. He tried to find a disease, which he could make fit into the patient's symptoms, not as we do today, make the patient fit into the disease. He laid emphasis on the patient not on the disease, on treatment, not on diagnosis. ( 26)

He described the physiology and anatomy of the eye in his book on psychology *De Anima*. He described the six extrinsic muscles of the eyeball. He put forward a theory of vision, which has been proven to be correct. He said that "*it is not a ray that leaves the eye and meets an object that gives rise to vision, but rather that the form of the perceived object passes into the eye and is transmitted by its transparent body, that is, the lens. "*

On the causation of disease he mentioned over indulgence, climatic conditions, surgical causes, contagion by drinking water. He classified smallpox, measles as contagious diseases. On the diagnosis of disease he put much emphasis on pulse and urine. He could diagnose a disease by 19 kinds of pain. He gave description of nervous and mental diseases. He divided mental diseases into elementary ( memory and imagination) and real psychosis such mania, melancholia, and feeble mindedness. He described brain tumors and stomach ulcers.

On relieving pain

Ibn Sena spoke of relieving pain through the application of hot compresses, massages, use of hot water bottle, pleasurable music, or engaging in compelling work. He further said that analgesics (mukhaddirat ) abated the pain, because they destroy the sensation of that part, which they do through hyper-cooling or by means of toxic property. Of the analgesics he considered opium the most potent,
two varieties of poppy, henbane, hemlock and lettuce seeds. He also included cold water and ice among the analgesics. He cautioned physicians to take due care in determining the cause of pain ensuring that it is not due to an external cause, such as heat or cold, hard or soft pillow, a poor bed, or a sudden fall due to drunkenness. He said often a good sleep and bathing is sufficient to relieve pain. Physician should decide which is more harmful, the pain, or the possible dangers or side- effects of analgesics.

His influence on the world of learning has been immense. Scores of Muslim authors and medical authorities have written commentaries on his books, and are being written even today, explaining the enormous power of his thought that has captured human imagination for centuries. He was fortunate to see the end of first millennium (Y1K) and beginning of second millennium (Y2K). Had he lived in this century he would have been awarded Nobel Prize for medicine, and perhaps Man of the Century.

**Abul Qasim al-Zahrawi** (1013- 1106)

He was born at the newly developed metropolis of Islamic Spain, Madinat az-Zahra, located 8 km from Cordoba. He was a practicing physician, a surgeon, and a pharmacist. Caliph Abdur Rahman III (912-961) appointed him court physician.

His magnum opus in medicine, al-*Tasrif leman ajiza ani alTaleef*, written around 1000 AD, is a voluminous work in medicine, and surgery, comprising of 30 treatises. It is further divided into two main parts, each consisting of 15 sections. The discourse on surgery is divided into three parts: 1. On Cautery 2. On incisions & bloodletting. 3. On Bonesetting. It was the result of 50 years of medical practice. In this work he discussed materia medica, cookery, dietetics, weights & measures, medical chemistry, therapeutics and psychotherapy. He discussed the symptoms and treatments of 325 diseases from head to toe.


Islamic Spain's outstanding surgeon

Gerard of Cremona translated the surgical part of this work into Latin in 12th century at Toledo; it remained leading textbook of surgery in medical schools of Italy & France. It was printed in Venice in 1497 along with French surgeon Guy de Chauliac's *Cyrurgia Parva*. John Channing's English translation was published from Oxford in 1778. A lithograph of poor Arabic text, with figures of instruments was published in 1908 from Lucknow, India.

. The observations contained in *al-Tasrif* are of a highly skilled surgeon, with more than 200 illustrations and descriptions of instruments, many of these modified, or new ones designed by him. For instance, he described a bevel-ended cannula, instead of the earlier one that was straight, for use in drawing off liquid when treating abdominal dropsy. He introduced a technique using a fine drill inserted through the urinary passage for treating a calculus impacted in the urethra. He also designed a concealed knife for opening abscesses in a manner that would not alarm the nervous patient. Giving diagrams of instruments in a book was a rare thing in those days, until Leonardo de Vinci's time. I had the pleasure of reading a manuscript of this great treatise on surgery at the Bodleian library in July 1999. In this book he described a hernia operation. For abdominal wounds he suggested holding together the edges of the wound and applying large ants.

He was the first to practice lithotomy on women. He introduced in obstetrics WALCHER'S position and devised obstetrical forceps. He gave descriptions for making knives, scalpels, & hooks of various shapes. He invented many types of surgical scissors and grasping forceps. He described eye operations in which he used pointed blades, speculums and, hooks. He applied plasters and bandages to bone fractures or dislocations and indicated paralysis attack following fractures of spine. He gave a description of hemophilia. He used wax and alcohol to stop bleeding from the skull during cranial operations. He used cautery to control bleeding.

As educator of the first order he dealt with such topics as child education, table etiquette, school curriculum and academic specialization. He recommended study of medicine by gifted students. He said brain includes three functions of intellect: thought, memory, and imagination.

He performed a thyroid operation. He devised a deep rectal syringe. He said that amputations should not be performed above the elbow or above the knee joints. He devoted a section of his book to stoppage of hemorrhage. He precisely described the operation for extracting stones from the bladder.

Realizing that his writings will be benefited by later generations, he observed " *I have described the methods of operations, I have illustrated necessary instruments and I have presented their forms by means of drawings. I have omitted nothing which can shed light on the profession."* A European scholar Martin Spink has reproduced sketches of 25 instruments from two manuscripts of al-Tasrif in the British Museum. He is of the opinion that these sketches were made from actual instruments, later copied into manuscripts of Latin versions of al-Tasrif.

As a skilled dentist he wrote on the treatment of deformities of the mouth and dental arches. For scaling teeth he used long handled scrapers fluted with good grip. He recommended the use of false teeth made from ox bone. He gave drawings of instruments that could be use for shaking, loosening, and extracting teeth. He described many dental operations such as fixation, re-implantation, artificial teeth, and extractions. He used gold threads to fix teeth because other metals would tarnish and cause a reaction in the mouth. His work on surgery was the basis for Western surgery.

As an ENT specialist he gave a description of removal of foreign bodies from the ear. Insects in the ears should be removed by suction or oily injections. As to the swelling of the tonsils he says these should be extirpated if they impede respiration.

He was a great psychiatrist who used drugs to induce hallucination, thrills, and happiness. He prepared an opium-based remedy and named it " Bringer of Joy and Happiness". On bedside clinical observation, he said, " only by repeated visits to the patients can the physician follow the progress of his medical treatment." As a gynecologist he described the mode of extraction by incision in female patients, but this observation was not primary as male surgeons could not operate on girls or married women. In this field his views were collected and translated into Latin as *Collectio Gynaecorium*. One of his other works in Latin was called *Libre Servitoris*.

His surgical writings were highly regarded in Europe. Much of the practice of reputed Italian surgeons of the 13$^{th}$ century was borrowed from az-Zahrawi. He was the greatest surgeon of Islam and a dominant surgeon of Europe for nearly five hundred years. Professor Neuberger says that al-Tasrif " by its method and lucidity awakened a prepossession in favor of Arabic literature." ( 27)

He described flora and fauna of Islamic Spain i.e. plants, animals, minerals. He described methods of purifying chemical substances as lethargy, ceruse. ( iron pyrite & vitriol). (28) Three parts of al-Tasreef 27, 28, 29 deal with materia medica. An alphabetical listing of these drugs is given also. The 18$^{TH}$ section deals with remedies derived from minerals and vegetables. He was the first physician to employ chemistry in the healing art of medicine. Az-Zahrawi's book in pharmacy was translated into Latin in 1471 *De Praeparatione Medicinarum* and was the first book in pharmacy printed in Europe.

Health Sciences library of Queen's University, Kingston, Canada has in its vast collection " *Albucasis, On surgery and Instruments"*, 853 pages, Arabic text with English translation and commentary, by M.S. Spink, Welcome Institute, London, 1973. Book one: On Cauterization, Book two: Incision, Perforation, Venesection, and wounds the Like, Book three : On Bone-setting. There are copious diagrams of instruments as given in different manuscripts ( Marsh & Huntington- Bodleian Library, Oxford).

Page 3 in the introduction states that " (al-Zahrawi) described many operative procedures, and instruments, which do not appear in extant classical writings, which may be regarded is own. The following instances merit special attention in this respect. 1. Tonsil guillotine & its use. 2. The concealed knife and its case for openings 3. He invented true scissors 4. He invented the syringe 5. The lithotrite 6. Designed vaginal speculum 7. He invented obstetric forceps (not for live delivery) 8. His use of animal gut as sutures material 9. Invented the formula for a kind of plaster- casing, anticipating the modern plaster cast.

*Zahrawi on tooth extraction*

*When, in extracting a tooth, a broken off root remains behind, you should apply to the place cotton wool soaked in butter for one or two days to soften it, then insert the tongs or forceps with stork-bill jaws as shown in the figure.*

*On treatment of things that fall into the ear*

*All that falls into the ear comes under four categories: mineral stone, or what resembles stone, such as iron or glass, vegetable grain such as pea or date-stone or the like, or liquid such as water or vinegar; or animal.*

*When a stone or something of that sort does not grow gets into the ear, turn the ear toward the sun. If you see the stone, pore upon it a little oil of sesame or violets, then try to get it out by moving of the head or by inducing sneezing with ptarmica & keeping the nose closed at the onset of sneezing. This will usually bring it out.*

His advice to all the surgeons was pertinent: " *God is watching you and knows if you are operating because surgery is really necessary or merely for love of money."*

**Abul Hassan Ibn al-Tilmiz (**Baghdad 1073- 1165**)**

Abul Faraj Yahya, a physician of repute, was Abul Hassan's maternal grandfather who made great efforts to secure a good education for his grandson. Upon completion of his medical education, he went to Persia, where he practiced medicine for several years. He learned the Persian language, as well as Syriac & Greek. He wrote short poems on general medicine, the value of learning, mental health, friendship, modesty, loneliness, romance, astrolabe, armor, and shadows.

In Baghdad he was physician to several Abbasid caliph including al-Muqtafi (1136-60) who appointed him court physician and chief of Adudi hospital. He was also commissioned by the caliph to conduct licensing examinations for doctors. He operated the largest private medical school in Baghdad, which attracted students from distant places.

Abul Hassan was an excellent educator and physician. His practice brought him immense wealth; he was very generous to his pupils and the poor. He collected a large library. He wrote 14 books, including pharmaceutical formularies, & medical commentaries. He was gentle by nature, eloquent, and friendly.

He wrote commentaries on leading Arabic medical works: Hunayn ibn Ishaq 's *al-Masail*, al-Razi's *al-Hawi*, Miskawayh's *al-Ashriba*, al-Masihi's *al-Mia* (100 books on medicine), ibn Sina's *al-Qanun*, ibn Jazar's *al-Minhaj*, and on *Tibb al-Nabi*. Thus he was first Christian physician to write commentaries on Muslim medical books. (29)

**Abu Merwan Ibn Zuhr** (1113-1199)

He was born in Seville, Spain where he built up his reputation early on as an outstanding physician. His family produced six generations of doctors, as was his son Abu Bekr Ibn Zuhr. He believed in the practice of medicine, as much as bedside observation. He attended the poor free of charge, but took high fee from the rich. He accumulated much wealth through his practice. He was court physician of Moahhed ruler of Seville Abdul Momin (d1163) to whom he dedicated his book on diets.

Ibn Rushd was his famous student who attended his lectures. They developed such a close friendship that he dedicated his work to Ibn Rushd, who in turn was so loyal that he copied his book al-Taysir with his own hands. Ibn Zuhr personally compiled Ibn Rushd's medical work al-Kulliyat that was meant to be a supplement to al-Taysir. A highly successful physician, who was endowed with a critical mind, he was inspired by the highest ideals.

*Al-Taysir feel Mudawat wal Tadbir* is his masterpiece in medicine, which contains clinical reports. He described some surgical operations with such thoroughness that it could have been possible only through practical experience. Copies of al-Taysir are preserved at National Library, Ribat, Morocco. He described paralysis of the pharynx and inflammation of the middle ear. He was the only Muslim physician who spoke of bronchotomy.

On one occasion when Ibn Zuhr was out of town, his son took such good care of his practice that he dedicated his book al-Tazkira to him. *Al-Tazkira* deals with therapeutics, fevers, and use of laxatives.
He advised doctors to use mild drugs and watch their patients for reactions, especially first two to three days. He explained that drugs mixed with honey or sugar were carried to the liver, which reacted to these substances. He described tumors, scabies, paralysis of the pharynx, and use of cold water for fevers. He emphasized the importance of clean air.

He had extensive knowledge of pharmacy. His book in this field contains simple and compound medicines. His book *fee Adwiya wal Aghziya* was translated into Hebrew in 1280; its first Latin version was printed at Venice in 1490. It appears from this book that he was director of a hospital in his native city.

Strangely he did not read any books written by medical authors of the Islamic east, but teachers of Toledo school of medicine earned his praise. (30) He wrote extensively on poisonous plants and antidotes. He described among other operations that for renal calculus and tracheotomy. He knew the itch-mite sarcoptes scabies.

He performed operative surgery though it was considered beneath a surgeon's dignity. He suggested removing stones from the bladder by the internal use of the oil of dates. He is credited with the first total extirpation of the uterus. He did operations on the animals for the sake of experiments.

He was the first to suggest nutrition through rectum. His apparatus for this purpose consisted of bladder of goat with a silver cannula fastened into its neck. Having first washed out the rectum with cleansing agents, he injected the nutriment - egg, milk, and gruel into the gut. He thought that intestine would take this and suck it up, carrying back into the stomach where it would be digested. He suggested this kind of feeding in cases of stricture of the esophagus. For treatment of esophagus, he inserted a cannula of silver through the mouth until its head met the obstruction. This was pushed firmly until it became engaged in the stricture. Through it freshly milked milk was to be poured. (31)

Professor Neuberger has paid him tribute in this way**:** **"** his memory remains that of a truly great practitioner, whose voice fell upon the deaf ears of his contemporaries & successors, but whose achievements heralded a new era of medicine.

He died at an advanced age due to a malignant tumor, and was buried near the Victory gate in Seville. Some of his other works are 1. Feel Zina ( on cosmetics and skin medications) 2. Feel Ilal al-Kila ( on kidney disease) 3. Fee Illatay Baras wal Bahaq ( on leprosy & vitiligo), 4. Al-Iqtisad feel Islah al-Anfus wal Ajsad (healing of body and soul) 5. Jami Asrar al-Tibb (secrets of healing art, discusses digestive system, function of liver, spleen, bladder, human physiology, gout, fevers, and hemorrhoids). 6. al-Tiryaq al-Sabini (describes seventy drugs). All his books were translated into Latin and Hebrew.

**Sayyid Ismaeel al-Jurjani** (d1136)

He was the first person who used Persian in his scientific writings. His best known work is gigantic *Zakhira Khawarazamshahi* (Treasury of King of Khawarism) which was acclaimed as the best textbook on science and medicine.

He also wrote *Aghraz al-Tibb* (Aim of the Medicine), *Yadigari Tibb* (Medical Memoranda) and the *Khuffe Alai* (Book of Exaltation). He popularized Arabic medical terminology, phrases, and terms which remained in Persian language. His descriptions of disease are true account of his personal observations. For instance in describing goiter and swelling of the throat he was the first to connect an exophthalmos with such swellings, a sign re-discovered by Parry in 1825. None of his works were translated into any of the European languages. **( 32)**

**Ibn Rushd 1126- 1198**

He was born in Cordoba, Islamic Spain where his grandfather was Imam of the Grand Mosque. He was born in a family of learned scholars and jurists. His father and grandfather were judges. He was by nature pensive, loathed to position and wealth. He passed most of his time in study and it was said that during his long life there had been only two nights when he could not study - on the night of his marriage and the other on the night of his fathers death.

In 1169 he became magistrate (Qazi) of Seville, then Cordoba, and in 1196 governor of Andalusia on account of his astonishing erudition. As a judge in Seville for 25 years he busied himself writing commentaries on Aristotle's books. Once he expressed his unhappiness over the fact that all his books were still in his hometown. In Cordoba he developed friendship with famous physician Ibn Zuhr who suggested him to study medicine. He requested his physician friend to write a book on al-Umur al-Juziya (treatment of head to toe diseases) which he did and called it *Kitab al Theisir*. Kulliyat of Ibn Rushd and Theisir were meant to be a comprehensive textbook. That is why some Latin translations contained both as one volume. He read a lot about medicine but had little hands on experience. He was a talented scholar who excelled in the art of reasoning.


Ibn Rushd statute in Cordoba, I visited this place in the Jewish district of the city during my visit there in 1999.

He studied medicine under Abu Jafar Harun al-Tajalli who was a noted teacher in Seville. Ibn Rushd entered the service of ruler of Seville Sultan Abu Yaqoob Yousuf (1163-84) who surrounded himself with leading scholars, philosophers, and physicians. He arranged meetings and debates between Ibn Tufail, Ibn Zuhr, and Ibn Rushd. Once prince Yousuf posed the question to the trio " if heaven is a substance that has always existed and will continue to exist, or if it has a beginning"? Ibn Rushds reply was brilliant; thereafter he enjoyed ruler's favors.

His major work in medicine is *Kitab al-Kulliyat* (General Rules of Medicine) which was written between 1153 and 1169. It is sub divided into seven books: *Tashrih al-Ada* (anatomy of organs), *Al-Sihha* (Health), *al-Marad* (on sickness), *al-Adwiya wal Aghziya* ( drugs & foods), *Hifz al-Sihha* ( Hygience), *Shifa al-Marad* (on therapy), *al-Alamat* (on symptoms of disease). An Italian Jewish scholar Banacosa made the Latin translation of Kulliyat in Padua in 1255, and first edition was printed in 1482.

Prof. Neuberger has stated that his book *Colliget* " *betrays extraordinary wide reading, a gift for adaptation and a mastery of dialectics. It is colossal commentary upon the first book of Canon. It presents little that is new; the practical contents may be looked upon as the ripe fruit of author's reading.* "
( 33)

He wrote a summary (Talkhis) of Galen's medical works, also a commentary on Ibn Sena's poem on medicine *Sharah Urjuza Feel Tibb*. A. Alpago translated into Latin his *Maqala feel Tiryaq* (Treatise on Theriac). (34) Though his philosophical works were burned, but not his medical works. Islamic medicine declined after his death in Morocco on December 12th, 1198 where he had gone to replace Ibn Tufail as royal physician. During his stay in Morocco he observed an unseen star.

In medicine his single most important contribution was his view that sense of sight originates in the lens of human eye. He also said that smallpox never befalls the same person more than once. He advocated that cause of disease must be sought beyond the patient himself. He surpassed Ibn Sena in applying Aristotelian principles of philosophy to medicine. His system of philosophy is known as Averroism. His scholarship had a deep influence upon advancement of science in Europe upto the 17th century.

His most celebrated pupil was Spanish Jewish philosopher Moses ibn Maimoon (Maimonides) while tried to reconcile faith and reason. Jewish philosophers took up his philosophy and spread his doctrines in France and Italy. He was more popular among the Jewish intelligentsia than his fellow believers who declared him a heretic because of his pantheistic views. He was deprived of his high position of Judge; his books burnt in a public square, and were put in prison in the Jewish town of Lucena, near Cordoba. He was restored to his high position before his death.

He wrote on the variety of subjects, mathematics, medicine, astronomy, logic, and Islamic jurisprudence. His writings cover more than twenty thousand pages. French scholar E. Renan has given a list of his 67 works in his book Averroes that includes 20 on medicine.

**Najeebuddin al-Samarqandi ( Herat - d 1222)**

He was a famous physician from Afghanistan who flourished at the time of Persian philosopher Fakhruddin ar-Razi (d1210). He died during the pillage of his hometown Heart by Mongols. His most important medical work is *Asbab wal -Almat* (etiology and symptoms of disease), a commentary on this work was written by al-Kirmani. He also wrote a book on the treatment of disease by diet and two medical formularies. His other works are:

*Al-Adwiya al-Mufrada* - *simple drugs*
*Aghziyat al-Marada* - *diet for the ill*
*Aghziya wal Ashriba* - *food and drink*
*Fee Mudawat waja al-Mafasid* - *cure of pain in the joints*
*Feel al- Tibb* - *on medicine*
*Fee kafiyat Tarkib Tabaqat al-Ayn* - *on the layers of eye*
*Feel Adwiya al-Mustamala Indal sayadila* - *drug preparation by pharmacist*



Al-Kirmani's commentary ( Sharh) was published by Maulvi Abdul Majid, Calcutta, 1836. *The medical formulary of al-Samarqandi* was published from Philadelphia, 1967.

**Abdul Lateef** (1162-1231)

He was born in Baghdad, where he studied alchemy and medicine in his youth. In 1189 he started his long journey to Damascus, Jerusalem & Cairo. In Damascus he taught medicine and philosophy, & took part in a debate with some city philosophers. He was victorious in this debate. He visited Jerusalem, and then onto Cairo where be became friend of Musa ibn Maimoon, the personal physician of Sultan Salahuddin Ayubi. Maimonides gave him the title of *Eagle of Doctors*. He gave public lectures in science and philosophy, soon returned to Damascus and continued giving lectures. He did more traveling and became personal physician of many Sultans.

In Egypt one day he was discussing superiority of observation over reading. Someone said that there were thousands of corpses in Maks exposed to sun. He went there to see these dead bodies. He noticed that the lower jaw consists of one bone, not two as described by Galen. He examined approximately two hundred jaws, got other people to see these as well, all arrived on the same conclusion. This was his single most important contribution in medicine that human jaw consists of one bone only.

He authored close to 150 medical works, only one has survived, *Compendium Memorabilium*, it was published from England in 1800 in Latin & Arabic. A French translation appeared ten years later from Paris.

**Aminu Dawla Ibn al-Quff** 22nd August 1233 - 1286 at Damascus

He was a master of many disciplines like medicine, physiology, natural science, and philosophy. He learnt medicine from Ibn Abi Usayba (1203-1270) who was much impressed with his aptitude for medicine. In his youth he read number of biographies and spent great deal of time in meditation.
His teacher asked him to study *Masai*l of Ishaq ibn Hunain and A*phorism*s and *Prognosi*s of Hippocrate. After reading these books he learnt the causes, symptoms and treatment of disease. In his commentaries he included sayings and annotations of Zakariya al-Razi.

He was appointed army surgeon at the citadel of Aljun in Jordan, then transferred to Damascus where he took up teaching medicine besides his official duties. He was a prolific writer. He wrote a commentary on *Isharat wa Tanbihat*, and *al-Mabahis* of Ibn Sena, both were unfortunately lost. He wrote ten books and commentaries on medicine, seven of which are preserved. His *Kitab al-Umda* is in twenty treatises, it superceded even the surgical compendium *al-Tasrif* of al-Zahrawi. In this book he described the important connection between the arteries and veins and the passage of blood and pneuma from the former to the latter. This reference was made four hundred years before Malpighi discovered this fact. He also explained the function of the cardiac valves, their numbers, and the direction in which they open and close.

His book on embryology is *al-Jami al-Gharad*, in which he spoke of how " *the head emerges from the shoulders ... and that brain is the first major organ to develop."* A manuscript is at Wellcome Institute of History of Medicine, London.

Following excerpt is from *al-Jami:*

*"The formation of a foam stage is the first six to seven days, which then in 13 to 16 days, is gradually transformed into a clot, and in 28 to 30 days into a small chunk of meat. In 38 to 40 days, the head appears separate from the shoulders and limbs. The brain and heart followed by the liver are formed before other organs. The fetus takes its food from the mother in order to grow and replenish what it discards. There are three membranes covering and protecting the fetus, of which the first connects arteries and veins with those in the mother's womb through the umbilical cord. The veins pass food for the nourishment of the fetus, while the arteries transmit air. By the end of seven months, all organs are complete…. after delivery, the baby's umbilical cord is cut at a distance of four-finger breadth from the body, and is tied with fine, soft woolen twine. The area of the cut is covered with a filament moistened in olive oil over which a styptic to prevent bleeding is sprinkled… After delivery, his mother nurses baby whose milk is the best. The midwife puts the baby to sleep in a darkened quiet room…. Nursing the baby is performed two to three times daily. Before nursing, the mothers breast should be squeezed out two or three times to get rid of the milk near the nipple".*

*Kitab al-Umda fee Sinaat al-Jiraha* was published from Hyderabad, India in 2 volumes in 1937. British Museum has several manuscripts besides National Library in Cairo and Bibliotheque Nationale, Paris. *Kitab Usul fee Sharah al-Fusul* and *Sharah al-Qanun* are commentaries; several manuscripts exist at National Library & Archives, Cairo.

There are two manuscripts of *al-Shafi fee al-Tibb* and *Zubdatu al-Tibb* at Rampur State Library, India and in the apostolic library in Vatican. Two other works in medicine are Risala fee Manafi al-Adha al-Insaniyya (utilities of organs of human body) and Fee Hifaz Sihat (Preservation of Health).

***Ibn Nafees 1213-1288***

He was born in a small town Kersh, near Damascus, educated at the college-hospital founded by Sultan Nurudin Zangi. He learnt Islamic jurisprudence, literature and, theology besides medicine. When he moved to Cairo he was appointed director of the famous Nasri hospital. He trained a large number of medical students, including Ibn al-Quff, the famous surgeon. He was an authority on religious law and a prolific writer of medical tracts. He specialized in eye diseases. He was the first director of recently constructed Mansuriyya hospital in Cairo, to which he bequeathed his house, library, and clinic. He was given the title of *Chief of Physicians*.

The encyclopedias written in medicine before were so big that a need arose to have these summarized for sake of ready reference. Ibn Nafees made an epitome of al-Qanun called *Kitab al-Mujiz* (the concise book), written while he was still in Syria. National Library of Medicine, Maryland, USA has a 17$^{th}$ century undated manuscript, written in a professional hand with an illuminated heading and opening text in cloud bands. MS. A44, 1, fol. 1B. The library has also in its possession a commentary on the Mujiz, called *The Key to the Mujiz,* composed in Arabic by al-Aqsarai (d 1370), dated October 1407.

His book *al-Shamil feel Tibb*, which he had hoped to have 300 volumes, remained incomplete due to his death. His treatise on ophthalmology is original and is also extant. He wrote a commentary on one of Hunayn ibn Ishaq's book. His book *Kitab al-Mukhtar feel Aghziya* is on effects of diet on health.

His most important contribution in medicine was the discovery of blood's circulatory system. To describe the anatomy of the lung he stated " *The lung is composed of first the bronchi, second the branches of the arteries a venosa and third the branches of the vena arteriosa, all of these are connected by loose porous flesh…. the need of the lung for the vena arteriosa is to transport to it the blood that has been thinned and warmed in the heart, so that what seeps through the pores of the branches of this vessel into the alvioli of the lung may mix with what is of air therein and combine with it …. and the mixture is carried to the left cavity of the heart by the arteria venosa.* "

He gave a description of bronchi and the interaction between body vessels for air and blood. He explained that blood is cleansed in the lungs by air breathed through the nose. He also explained the function of coronary arteries as feeding the cardiac muscle. Michael Servetus, Spanish physician, re-discovered circulatory system of blood three hundred later.

Certificate by ibn Nafis

National Library of Medicine, Maryland, USA has a signed statement made by him, that his Christian student Shamsu Dawla al-Masihi had read and mastered Ibn Nafis's commentary on a Hippocratic treatise. This certificate is in his own hand and dated $29^{th}$ of Jumada 668 (25th January 1270). It states:

*In the name of God the, Provider of Good Fortune. (wa Allah al-Muffiq )*

*The wise the learned, the excellent Shaykh Shams al-Daulah Abu al-Fazl ibn al- Shaykh Abi al-Hassan al-Masihi, may God make long lasting his good fortune, studied with me this entire book of mine - that is, the commentary on the book of imam Hippocrates, which is to say his book known as ' On the Nature of Man' - by which he demonstrated the clarity of his intellect and the correctness of thought, may God grant him benefit and may he make use of it.*

*Certified by the poor in need of God, Ali Ibn Ali al-Hazm al-Qurashi ( known as ibn al-Nafis)the physician. Praise be to God for his perfection and prayers for the best of His prophets, Muhammad, and his family. And that it is on the $29^{th}$ of Jumadi Awal ( in the year six hundred sixty eight.)*

*Bibliography:*


1. History of Science, by George Sarton, page 565
2. Arabian Medicine, E.G. Brown, page 39, 1939 Cambdrige
3. Tahzeebul Akhlaq, Aligarh, India April 1989
4. Al Judri wal-Hasba, English Tr. by Greenhill, page 137, 1848.
5. Medicine in Persia, E.G. Brown, page 37 NY 1934
6. Encyclopedia of Islam, Vol 8, 474
7. History of Medicine by Max Neuberger, page 361, 1910
8. Arabian Medicine, page 44
9. Greenhill, page 83, 1848
10. Encyclopedia of Islam, Vol 8, 474
11. Story of medicine, by David Riesman, page 52, NY 1935
12. Greenhill, page 117, 1848
13. Prophet's Medicine by I. Perho, page 116, Helsinki 1995
14. Pharmacy in the middle ages by Hakim M. Said, page 81, Karachi 1980
15. Illustrated history of medicine by R. Margotta, page 20, London 1967
16. Medieval Medicine by James Walsh, page 36, London, 1920
17. Dictionary of Scientific Biography, Vol 15, page 184
18. Al Tibb ar-Ruhani english transaltion A.J. Arberry, pp 64-72, 1950
19. Story of Medicine, pages 348/ 349, NY 1935
20. History of Medicine by Neuberger, page 365

*21.* DSB Vol. 9, page 40
*22.* Arabian Medicine by Browne, page 124
*23.* Neuberger, page 367 & 368
*24.* Pharmacy in the Middle Ages, page 107
*25.* Parmacy in the Middle Ages, page 83
*26.* Medicine in Persia, by Elgood, page 193, 1950
*27.* Neuberger, page 366
*28.* DSB, Vol 16, page 584
*29.* DSB, Vol 13, page 196
*30.* History of Medicine, by B.L. Gordon, page 208-213
*31.* Medieval Medicine by J. Walsh, page 78, 1920
*32.* DSB, Vol 12, page
*33.* DSB Vol 12, page 90

Chapter 5

# The Arab Galen
# Abu Bakr Zakariya Al-Razi (854-26th Oct. 925)

Abu-Bakr Muhammad bin Zakariya Al-Razi is considered to be one of the greatest clinical physicians of medieval world. His authority in medicine is second only to Shaikh-al Rais Ibn Sena (Avicenna*)* but in regards to observational powers Al-Razi was far superior to Ibn Sina. Al-Razi was an accomplished physician, philosopher, physicist and an empirical chemist. His insight, sharp intellect and encyclopedic knowledge earned him the title of '***Arabic Galen***.' He was a master of prognosis and psychosomatic medicine.

Al-Razi was born around 844 in Rayy (near Teheran) as the name al-Razi indicates. He studied philology, mathematics, philosophy, logic, chemistry, and music, but at age 30 he devoted himself to medicine. In his youth he was a great lute player. He traveled to Baghdad to study medicine, subsequently becoming director of Royal Hospital in his native Ray. While in Baghdad, he learnt the art of healing from a well-known physician Ali Bin Sahal (d 870) who was superintendent of all government hospitals. Ali Bin Sahal devised new methods for treatment of diseases, documented all cases in his diary. Subsequently this diary was published as '*Firdaus ul Hikma'* which was arranged alphabetically. This book was in fact first medical encyclopedia of the world.

Later Razi was appointed director of *Muqtadiri Hospital,* located in al-Karkh quarter of Baghdad, near the bridge over the Karkhiya canal. During his stay at the hospital he copied extracts from a book of prescriptions which was at the disposal of a hospital doctor, entitle *Tajarib al-maristan* (hospital experiences) including the actual prescriptions. Manuscript of this book is at Bodleian library Oxford, MS Marsh # 537.

In Baghdad Razi was a respected teacher and court physician to Buwayhid Emir Adud-al-Daulaw (949-83). As director of the Baghdad General Hospital he chose a site for its building by suspending shreds of meat in different locations of the city and finding out where the least sign of decomposition appeared. Here he performed the duties of both hospital director and dean of medical school. He issued instructions to have a ward exclusively devoted to the mentally ill.

Al-Razi traveled to many distant cities for the purpose of acquiring knowledge, was in touch with eminent scholars of his time. He authored close to 200 works in philosophy, astronomy, physics, chemistry and medicine. He was a Persian but most of his works were composed in Arabic, which was *lingua franca* at the time. He was highly esteemed for his learning, diagnosis and therapeutic skills, which was based upon observation of the course of the disease and laying stress upon hygienic and dietetic measures. Prof. S. Hossain Nasr observes: "*The skill of Rhazes in prognosis, and his analysis of the symptoms of a disease, its manner of treatment and cure, have made his case studies celebrated among later physicians". (Nasr, Science and Civilization, page 196, 1987).*

He was a tireless writer of immense productiveness and versatility, and an inspired teacher. He advised his students while they were examining a patient to bear in mind the classic symptoms of a disease as given in a textbook and compare them with what they observed.

Al-Biruni, the celebrated scientist from present Afghanistan, prepared a catalog of al-Razi's books and treatises numbering well over 184. Most of these books have been lost but some have survived through Latin translations. This catalog was published in German in 1924 from Berlin under the title ' *Al-Biruni als quelle fur das leben and die schriften al-Razi'.*

It was characteristic of al-Razi to set greater value upon description of disease than upon theoretical speculation as is evidenced from his medical works which contain numerous clinical histories which are proof of his admirable powers of observation. He expanded great care upon diagnosis and prognosis.

Razi totally trusted human reasoning. There was no one above his criticism, he challenged tradition and authority in every field he turned his attention to. Although he was convinced of the intellectual status of Socrates, Plato, Aristotle, and Galen but he was not afraid of their authority. He was of the opinion that "*the creator (Exalted be His name) gave and bestowed on us reason to the end that we might thereby attain and achieve every advantage, that lies within the nature of such as us to attain and achieve, in the world and the next. For by reason we understood the manufacture and use of ships, …. By it we have achieved medicine with its many uses to the body, and all the other arts that yield us profit…. By it we have learned the shape of the earth, and the sky, the dimensions of the Sun, Moon and other stars, their distances and motions".*

*al-Razi*

Kitab al-Hawi fil Tibb

Al-Razi's magnum opus, *Kitab al-Hawi* (Comprehensive Book) represents the fruit of a long life spent in writing this illustrious work. It contains an astounding mass of extracts from Greco-Arabic and Indian literature, as well as numerous records from his own medical practice.

Al-Hawi contains the thoughts, original observations, and clinical notes of his entire medical life.

This encyclopedia of medicine was used as a textbook in numerous European universities for 500 years, from 12th to 17th century. During this period Galen, Razi and Ibn Sina were considered the giants in the field of medicine.

السلسلة الجديدة من مطبوعات دائرة المعارف العثمانية ١٠٤

أبو بكر محمد بن زكريا الرازى الطبيب

المتوفى سنة ٣١٣ھ / ٩٢٥م

# كتاب
# الحاوى فى الطب
## ( الجزء العاشر )
## فى أمراض الكلى و مجارى البول و غيرهما

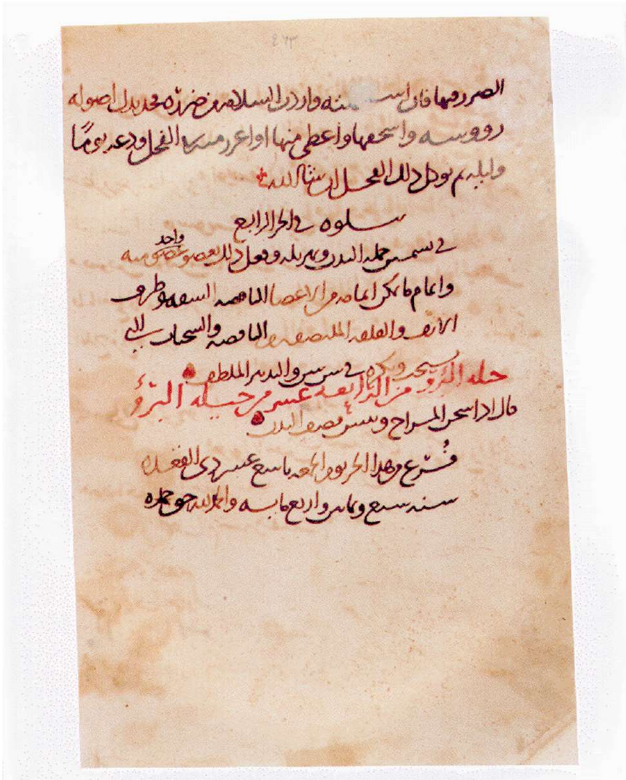
صُحِّح

عن ثلاث نسخ قديمة محفوظة فى المكاتب الشهيرة احدها فى مكتبة إسكوريال
[رقم ٨١٣] مدريد ، و هى الأساس للتصحيح ، و الثانية فى مكتبة لئن
عليگڈه مسلم يونيورسٹى و الثالثة فى مكتبة نيشنل ميوزيم بدهلى
باعانة وزارة التحقيقات الحكمية و الأمور الثقافية للحكومة العالية الهندية

الطبعة الأولى

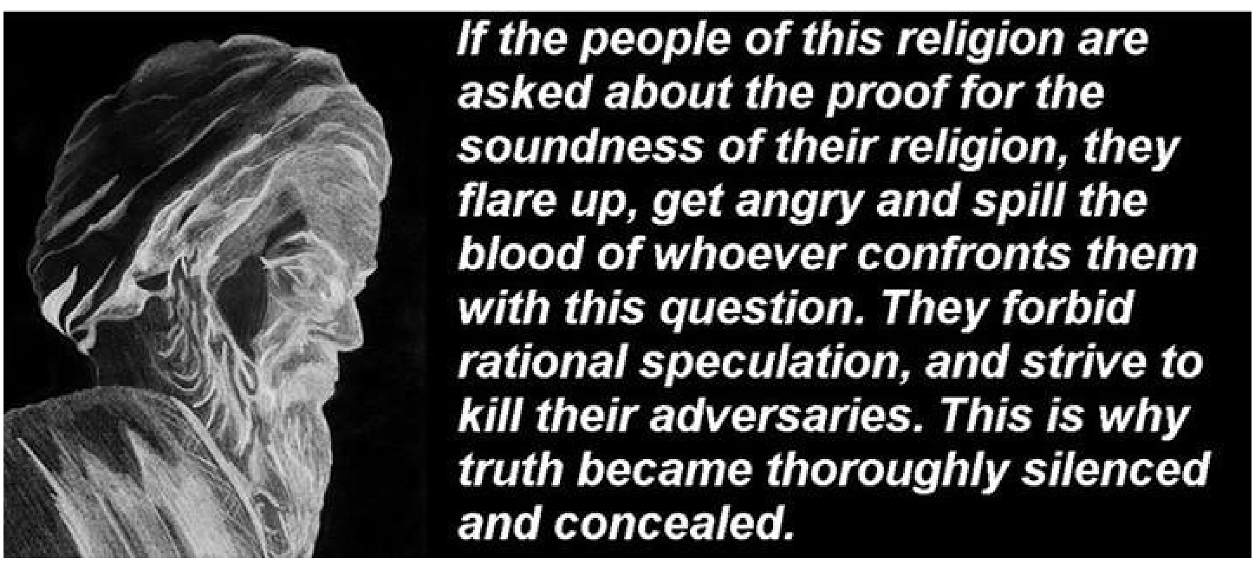
بمطبعة مجلس دائرة المعارف العثمانية بحيدر آباد الدكن الهند

١٣٨٠ھ ١٩٦١م



Last page of kitab al_hawi

*Al-Hawi,* was translated into Latin by a Sicilian Jewish scholar Faraj Ibn Salim in 1279 under auspices of Italian King Charles I of Anjou (1220-1285) as *Liber Continens*. This enormous twenty volume medical encyclopedia was the largest ever composed by one person.
A Latin edition was printed in 1486 under the title *Liber dictus Alhavi*, the last edition printed in Venice in 1542. By 1866 40 editions had been printed in Europe. A copy of the Latin translations in stored in Kings College library at Cambridge University. Al-Hawi was published in Arabic text from Hyderabad, India in 1955. Following diseases were discussed in detail: renal abscesses, aortic regurgitation, ophthalmia, spitting of blood, temporary baldness.




Under the auspices of Literary Institute of Unani Medicine Delhi (LRIUM) his *Kitab al-Mansuri, Kitab al-Abdal, Kitab al-Fakhir fil Tibb, & Kitab mal Fariq*, the Arabic editions as well as Urdu have been published. Kitab al-Hawi has been translated into Urdu, and 10 volumes have so far been published from India (2013).

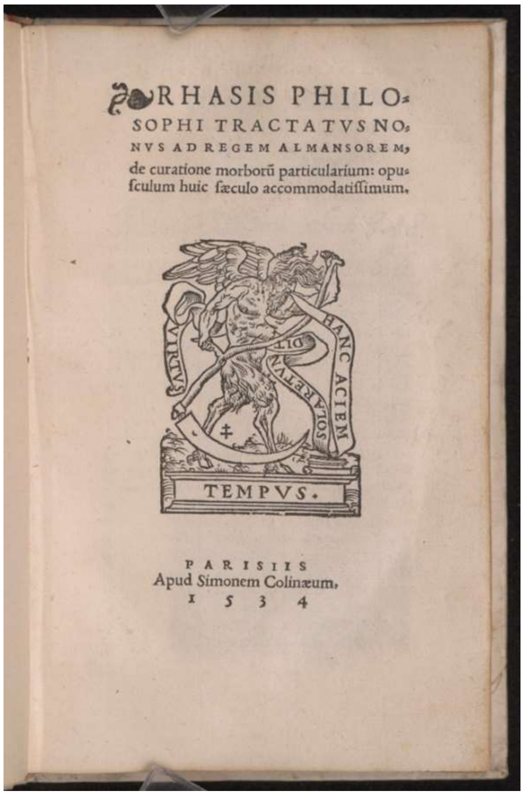
Kitab al-Mansuri fil Tibb

Razi other most important book on medicine is *Kitab al-Mansuri* which comprised of ten volumes and dealt with Greco-Arab medicine. Some volumes of this work have been published separately in German and French. It was translated into Latin ' *Liber Almansoris'* in 1264 by Jewish physician and philosopher, Shem *Tob* at Marseilles. Later in 1480, the ninth volume which was translated by Italian scholar Gerard of Cremona (d.1187), was published as "*Nonus Almansoris*". In this work he devoted a chapter to anatomy giving a detailed description of various organs of the human body, including sensory and motor parts. He gave elaborate description of spinal cord, and stated that injury either to the brain or spinal cord can lead to paralysis of the parts of the organs whose nerve supply is damaged. This was used as a standard textbook in European universities of Montpellier, Bologna, Paris, and Oxford until sixteenth century. For a long time al-Mansuri was in a manuscript, but it has now been printed from India.

In Kitab al-Mansuri he observed how airborne germs can cause infectious diseases: "Among *the things that are infectious are: leprosy, scabies, consumption and epidemic fever, when one sits with those who are afflicted in small houses and downwind (from them). Often ophthalmia infects by being looked at, and often (the condition of) multiple evil unlcers is (also) infective. Generally speaking in every illness which has putrefaction and (bad) air, one should distance oneself from the afflicted or sit upwind from them.* " *al-Mansuri*, French Trans. De Koning, Bodleian Marsh

Colic was a common disease during Razi's lifetime. This is what he had to say about this abdominal affliction: " *I have seen that dry colic only occurs in those with melancholic temperament, for the latter's nature is always dry; as to those with very moist temperament, they only get distended from colic and they may be protected from it by avoiding pulses and fruit. As for those with hot temperament and choleric temperaments, they get constipation without distension, and that is because of excessive heat … as for those with hot, moist temperaments, they are the least likely of people to get colic*. "

*Will Durant has observed: al-Hawi was one of the nine volumes constituting the whole library of Paris Faculty of Medicine in 1395"*

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Latin translations of Kitab al-Mansoori

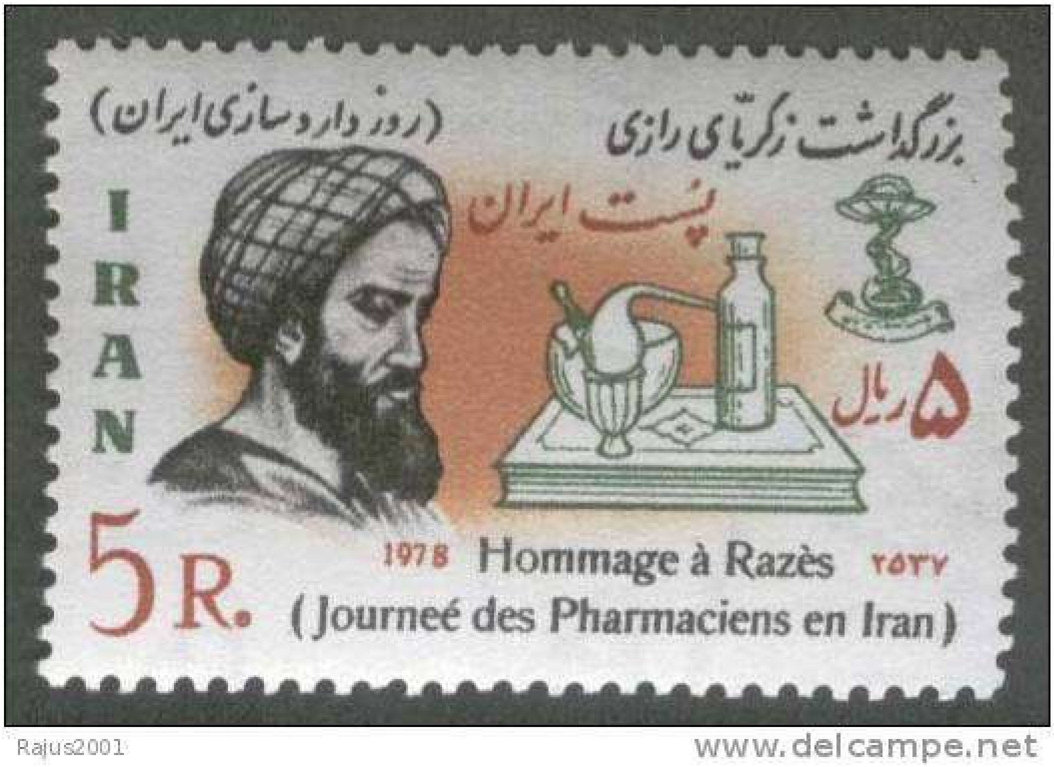
Al-Mansuri consists of 10 treatises, third one devoted to diets, drugs, cereals, dairy products, fruits and legumes. The 8th treatise is on toxicology and theriacs. It was translated into Latin *Liber ad Almansorem* by Gerrard of Cremona. In maqala 10 Razi gave names of 13 types of fevers: humma yaum, humma al-diqq, humma al-ghibb, humma al-muhriqa, humma al-balghamiyya, humma al-rub, humma al-mukhtalita, humma ma'al harr wal-bard, humma al-ghashy, humma al-warram, humma al-waba, humma al-murakkaba, al-judri wal-hasba. A manuscript of al-Mansuri is preserved in Bodleian Library, Marsh 376, and Oxford. There are sections on anatomy, diseases, including the eye and their treatment. Razi originality is clearly shown in evidence based medicine, clinical observations as well as in psychological medicine.

Ophthalmology

There are some sections in the al-Mansuri that deal with anatomy, disease including eye ailments and their treatments. This was covered in Kitab al-Hawi al-Kabir and al-Taqsim wal Tashjir. His originality is evident in clinical observations. (S.K. Hamarneh, Arabic ophthalmology in Essays on Science by H.M. Said, Hamdard, Karachi 1987 pp 75-89)

Dentistry

*Kitab al-Mansuri* is probably the first treatise on dental anatomy written by a Muslim. He correctly stated there 32 teeth, 16 in each jaw. For daily care he recommends use of miswak (twig) along with a powder made from myrrh and alum, salt, and hartshorn. He treated black teeth with dentifrices. He believed toothache was caused by penetration of mucus into roots of teeth or air sealed in teeth. He recognized that toothache may result from extreme hot or cold. For relief from toothache he recommends the tooth with a drill. He cured cavities with a wool compress dipped in boiling oil. He preferred not to extract teeth that were loose, preferred gold wire ligatures. In the case of gingivitis abscess he recommended cupping the tooth.




Iranian postage depicting al-Razi

He wrote two treatises on ethics of medicine that have been published; *Kitab al-Tibb al-Roohani* (translated by A.J. Arberry entitled *The Spritiual Physick of al-Razi*) & Sirat al-Faylasuf (philosophers way of life). He warned that even highly educated doctors did not have the answers to all medical problems and could not cure all sicknesses or heal every disease. To become more useful in their services and truer to their calling, Razi advised doctors to keep up with advanced knowledge by continually studying medical books and exposing themselves to new information. He made a distinction between curable and incurable diseases.

Several manuscripts exist of his work entitled *al-Shakook ala Jalinus* - *Doubts Concerning Galen.* In this he criticized & rejected Galen's theory of four humors. Razi rejected several claims made by the Greek physician, i.e. superiority of the Greek language and many of his cosmological and medical views. He links medicine with philosophy, and states that sound practice demands independent thinking. He reports that Galen's descriptions do not agree with his own clinical observations regarding the run of a fever. And in some cases he finds that his clinical experience exceeds Galen's.

> "His writings on smallpox and measles show originality and accuracy, and his essay on infectious diseases was the first scientific treatise on the subject." –
> The Bulletin of the World Health Organization (May 1970)

Razi's name lives on in Muslim communities around the world. The Ar-Razi Medical Centre in Leicester, UK, is part of the British National Health Service.

Use of Psychotherapy

Al-Razi made use of psychotherapy with dramatic results, antedating Sigmund Freud by a thousand years. It is stated that he was called to treat a famous Caliph who was suffering from severe arthritis. He advised a hot bath, and while the Caliph was bathing, Razi threatened him with a knife, proclaiming he was going to kill him. This deliberate provocation increased the natural caloric which thus gained sufficient strength to dissolve the already softened humors; as a result the Caliph got up from his knees and ran after him.

Psychosomatic medicine

Razi was an authority in neurological and psychiatric illnesses. In the first part of his book al-Hawi he dealt with illnesses relating to head like apoplexy, tremors, motor and sensory disorders, in addition to torpor, lethargy, and melancholy. He spoke about faculties of the brain like imagination and memory, distortion of vision. He touched on facial palsy (Bell's palsy), epilepsy, night terrors, nightmares, tetanus, headaches and migraine.

To test the treatment of delirium he divided the sick into two groups, treated one group with blood-letting but not the other group, then did a comparison of patients. This method is still established and is used in modern medicine until today. (M. Kamil Husayn, Tibb al-Razi Dar al-Shuruq, 1977, pp 33-94 – quoted in Science & Technology in Islam, UNESCO, part 11, 407)

Razi realized that psychological factors cause illness i.e. dyspepsia. He employed diversion, music, recreation, reassurance in the treatment. He chose foodstuff over drugs in the prevention of disease. He had the ability to know people's disposition and how to treat each person. His book on the principles of physiognomy was published from Aleppo in 1929.

In his book Tibb ar-Ruhani he wrote on psychology: sleep, pleasure, grief, carnal desire, habit, and balance of reason.

Al-Razi also developed a pleasure-pain theory: "***Pleasure consists in the restoration of that condition which preceded the suffering of pain. A man leaves a restful, shady spot to go out into the desert; there he proceeds under the hot summer sun, is affected by the heat; he goes back to his former place where he experiences pleasure until his body returns to its original condition. The intensity of his pleasure in coming home is in proportion to the intensity of the heat he had suffered. Since pain sometimes sets in and increases gradually over a period of time, and the return to the original state Often occurs quite suddenly, we do not become aware of the element of pain at once, while the sharpness of the*** *return* ***to the original state is keenly and pleasurably felt***"*. Arabic Thought and the Western World, page 14, by Eugene Myers, New York, 1964*

In another book *The Classical Heritage in Islam*, the nature of pleasure is described in this way:

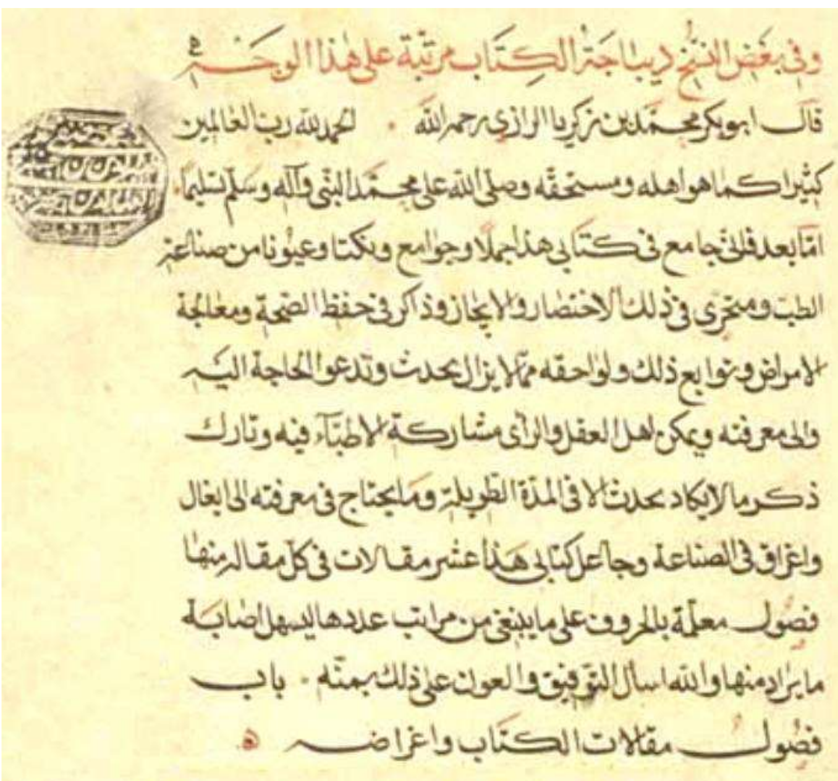
" ***Pleasure is nothing more than a respite from pain, and pleasure exists only in the wake of pain…….when pleasure lasts it becomes pain……… pleasure is a liberating perception of the senses, and pain a painful one…. Sensual pleasure is nothing more than a respite from pain, and pain nothing more than forsaking nature. Nature is neither pain nor pleasure…… The pleasure of copulation is caused by the accumulation of a certain substance in a particularly alert and sensitive place. When that substance is long accumulated there and then suddenly leaves that place, this produces pleasure.. it is comparable to the pleasure derived from scratching when it itches…….. The pleasure felt at the sight of beautiful faces is explained by arRazi in the sense that people tire of unattractive and ugly companions and thus forsake their natural condition. Everyone who hears soft sounds after***

***harsh ones feels pleasure………. Everybody feels pleasure when he sees light, but when he* sees a great deal of light, closing of the eye and darkness also give him pleasure" (By Franz Rosenthal, page 103,London, 1975).**

Al-Razi (*Rhazes* in Latin) was a pioneer in many areas of medicine and treatment in general. In particular, he was a pioneer in pediatrics, obstetrics and ophthalmology. Some of his medical works e.g. *Kitab al-Mansoori, Kitab al-Hawi, Kitab al-Mulooki and Kitab al-Judri wal Hasabah* have earned him an everlasting fame. His treatise on smallpox was published for the last time from London in 1847. His views & experiments in chemistry are given in *Kitab al-Asrar wa sirr al-Asrar,* published from Tehran in 1964. Only fragments have been preserved of his treatise al-Ilm al-Ilahi (the Divine Science) which contains his cosmogony.

An outstanding feature of his treatment was that he favored cures through properly regulated food. He would try his remedies first on animals in order to evaluate their side effects.

His clinical observations have been edited by Max Meyerhof entitled '*Thirty three clinical observations by Rhazes*". Al-Razi indicated that on some points his medical experience was much more abundant that Galen. Razi regarded soul as a substance. He thought that the brain was the instrument of the soul. Al-Biruni admired him as a master physician, while Ibn Sena suggested that Razi should have confined him self to dealing with medicine instead dabbling in philosophical problems.


وفي بعض النسخ ديباجة الكتاب مرتبة على هذا الوجه
قال ابو بكر محمد بن زكريا الرازي رحمه الله . الحمد لله رب العالمين
كثيرا كما هو اهله ومستحقه وصلى الله على محمد النبي وآله وسلم تسليما
اما بعد فاني جامع في كتابي هذا جملا وجوامع ونكتا وعيونا من صناعة
الطب ومتحري في ذلك الاختصار والايجاز وذكر في حفظ الصحة ومعالجة
الامراض وتوابع ذلك ولواحقه مما لا يزال يحدث وتدعو الحاجة اليه
الى معرفته ويمكن اهل العقل والرأي مشاركة الاطباء فيه وتارك
ذكر ما لا يكاد يحدث الا في المدة الطويلة وما يحتاج في معرفته الى ايغال
واغراق في الصناعة وجاعل كتابي هذا عشر مقالات في كل مقالة منها
فصول معلمة بالحروف على ما ينبغي من مراتب عددها ليسهل اصابة
ما يراد منها والله اسال التوفيق والعون على ذلك بمنه . باب
فصول مقالات الكتاب واغراضه

Razi book on anesthesia composed 1000 years ago

**He is associated with several technical innovations** e.g. he was the first person to use alcohol as antiseptic and used opium for the first time as anesthesia. He made medical use of mercury as purgative (after testing this on monkeys), this drug was called '*Album Rhasis*' during the Middle Ages. He was the first physician to find stones in bladder, and he was the one who used seton in surgery. He was the first person to give an amazing account of the operation for the extraction of a cataract and also the first scientist to discuss the pupillary reaction or the widening and narrowing of the pupil of the eye to light. He explained that this reaction was due to the presence of small muscles that react to the intensity of light.

His treatise on ophthalmology, was rendered into German language in 1900 by W. Brunner. Also he was the first one to use animal gut for surgical sutures and used plaster of Paris for casts to heal broken bones. He checked the enthusiasm for urinalysis in an age when physicians were prone to diagnose ailments by examining the urine, sometimes even without seeing the patient. His interest in Urology focused on ailments involving urination, venereal disease, & renal abscess. He described hay fever or allergic rhinitis also. In his scholarly work on eye diseases '*Monograph on the Eye'* he repudiated the theory that light emanates from the human eye whereby things become visible.

During the Middle Ages a medical student was required to study the following text books: Aphorism of Hippocratic, Questions of Hunain Ibn Ishak, Guide of al-Razi, Treasury of Sabit ibn Qurra, al-Mansuri of al-Razi, Sixteen Treatises of Galen, Kitab al-Hawi of al-Razi and lastly al-Shifa of Ibn Sina.

### Ophthalmology

Razi wrote a treatise in which he said sight does not come about through rays leaving the eye, as was believed then, but by rays of light starting from the bodies perceived, approaching the eye; so the bodies emitting rays are sources of light, not an instrument. Regarding the nature of light he said it is spontaneous or accidental. He explained the importance of dark room on which the idea of *camera obscura* is based.

### Cosmetic Surgery

If a person's lip, nose or ear is smaller or larger than normal, he offered cosmetic surgery for such a person. "*When it is a case of fibromatous swelling that makes an organ smaller, such as lip the nose or the ear, one should incise the middle, peel back the skin on both sides of the incision, and cut the flesh that is in the middle, which is hard, and throw it away, then join the skin by sutures without removing any of it. In this the organ resumes its normal size because what was deforming it has been removed*". Kitab al-Hawi, Vol. V, page 218 & 219.

He described the how to suture the abdomen wounds. "If the abdominal wall is pierced through so that some organs come out, it is necessary to know how to gather up the intestines and put them back in." Kitab al-Hawi, Hyderabad, page 205

### Diseases of the Children

Razi was the first person in the world to write a book on pediatrics- Risala fee *Amraz al-Atfal (Epistle on the diseases of Infants)*. Razi divided off the study of pediatrics from gynecological disorders, making it independent. The Arabic was translated into Hebrew, Latin and recently into German and Italian. Samuel Radbill translated it into English and published in the American Journal of Paedriatics in 1971. Since the Arabic original was lost, it was translated back into Arabic and published in Proceedings of the Regional Conference on Childhood, Baghdad, 1979.

The treatise has 24 chapters, including Razi opinions on pediatrics. He disagrees with opinions of Greek as well as Arabic physicians. He divides children's diseases according to their age. (Mahmud al-Hajj Qasim, Different aspects of Islamic Culture, Part II, page 388)

About the diarrhea in children he says:

"*Diarrhea is recurrent in infants and it is caused by their appearance of teeth, of because of cold, when they are swaddled, or because the milk is tainted with bile or phlegm. The sign of bilious cause is that the infant faeces will be lemon colored, sharp smelling, and excreted without any pause. The sign of cold and phlegm is that the faeces are white and are excreted intermittently; when the phlegm is viscid, the faeces comes fast. "*

*(Risala fee amrad al-atfal, translated into English by Samuel Radbill, Roneo Publication 1979, Arabic editions by Mahmud al-Hajj Qasim Baghdad, Roneco Publication.)*

### Contributions to Chemistry

Al-Razi was very much influenced by famous Iraqi chemist, Jabir Ibn Hayyan though he developed his chemistry independently. His monumental work on chemistry *Sirr al- Israr* (Secret of Secrets) was translated into Latin as 'Liber *Secretorum Bubacaris'* in which he has discussed several chemical reactions in distillation, calcination and crystallization. He has given full description of about 25 instruments he used in his laboratory such as Beakers, Shears, Tongs, Alembies, Pestels and Mortars, bellows, hammers, sieves, filters, phials, flasks, beakers, cauldrons, files, blacksmith's hearths, and lamps for imparting a gentle heat.

He has been credited with inventing *sulfuric acid*. He classified chemical substances into mineral, vegetable and animal thus laying foundation for organic and inorganic chemistry. He explained that all living bodies are made up of living cells which depend upon intricate chemical reactions.

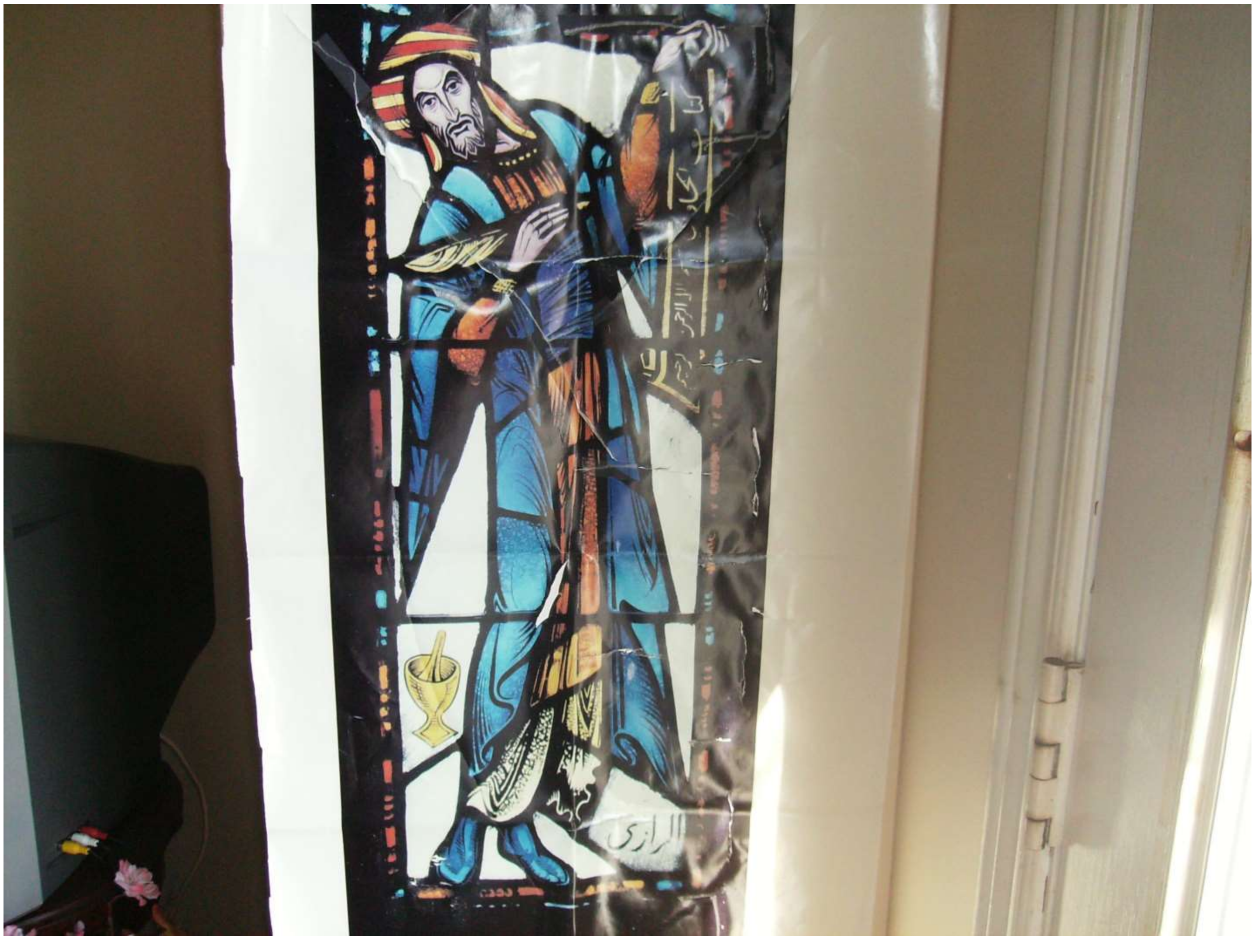
He classified chemical substances as follows: Spirits (al-arwah): mercury, sal ammoniac, arsenic, sulphate, sulphur,. The Bodies (al-ajsad) gold, silver, copper, iron, lead tin. The Stones (al-ahjar) pyrites, iron oxide, zinc oxide, malachite, turquoise, arsenic oxide, glass Vitrio (al-zajat) alums, green (qalaqand), yellow (qulqutar) borax (albawariq), Salts (al-amlah) animal substances, hair, scalp, brain, bile, blood, urine, eggs, horn & shell.

His books on Chemistry: *madkhal ta'alimi, asbat sana't, kitab sang, kitab tadbir, kitab akseer, kitab sharf san'at, kitab tartib, kitab rahat, kitab tadabir, kitab shawahid, kitab asmai'sh zar-w-seem, kitab sir hakeeman, kitab sir, kitab sir al-asrar, risail bay faan, arzoo-ey-arzoo khawah, kitab tabweeb.*

Book on Smallpox and Measles-
Ornament to medical literature

It was characteristic of al-Razi to cite Greek, Syriac, Persian and Hindu opinions on a given question and then present his views. This independent attitude enabled him to make some remarkable discoveries, above all to distinguish for the first time differences between smallpox and measles. His work *Kitab al-Judri wal-Hasba* brought him lasting fame and is considered as an ornament to the medical literature. It ranks high in importance in the history of epidemiology as the earliest work on smallpox. He describes the initial symptoms of smallpox & measles with care - the first vivid description of disease appearing in medical literature. Thereupatic measures prescribed are the result of many years of clinical experience. For centuries it has remained a masterpiece of direct observation and clinical analysis. Here is an excerpt from this monograph on these two diseases.

"*The outbreak of small-pox is preceded by, continuous fever, aching in the back, itching in the nose and shivering during sleep. The main symptoms of its presence are: backache with fever stinging pain in the whole body, congestion of the face, sometimes shrinkage, violent redness of the cheeks and eyes, a sense of pressure in the body, creeping of the flesh, pain in the throat and breast accompanied by difficulty of respiration and coughing, dryness of the mouth, thick salivation, hoarseness of the voice, headache and pressure in the head, excitement, anxiety, nausea and unrest. Excitement, nausea and unrest are more pronounced in measles than is small-pox, whilst the aching in the back is more severe in small-pox than in measles."*



This is portrait of Razi on the stained glass of a window in Princeton University, New Jersey, USA. Author of this article has a copy of this magnificent portrait of Razi.

His book on measles was translated many times in Latin 1498, French 1763 German 1911 and English (Ueber die Pocken und die Masern (ca. 900 n. Chr. aus dem Arabischen ). Between 1498-1866 forty editions were published in various languages. Bracken Health Sciences Library of Queen's University Kingston, Ontario Canada has a rare & valuable copy of this book in German and English dated 1911. www.queensu.ca .

Al-Razi has mentioned 24 contraceptive recipes, mechanical as well as chemical in his book *Quintessence of Experience, section 'on the means of preventing conception'.*

Invention

To weigh drugs precisely and accurately he invented Mizaan Taba'yee – Hydrostatic balance. Its description is: *"the hydrostatic balance of al-Razi was equal armed, but the suspension of one of its own pans could be moved along the beam. He introduced the indicator tongue (al-lisan) into the design. "*

Philosopher

Al-Razi's contribution as a philosopher is no less compared to medicine. He studied Platonic, Stoic, and Epicurean philosophy and took as his hero Socrates, the great questioner of ideas and values. In his book *Sira al-Falsafiya* (conduct of a philosopher) he said that indulgence in enjoyments of life and total abstemiousness is bad. He said that some people deny themselves lawful pleasures as training in self-control which is not healthy.

His questioning of Islamic beliefs led him to doubt the validity of religious teachings and caused orthodox Muslims (Ismailies) to destroy his philosophical works. When he lost his eyesight through cataract, it was assumed to be God's punishment for his heretical beliefs. He stands unique among Muslim philosopher who urged the use of reason for self-development.

In his book on ethics ' ***The Spiritual Physick*** ' this is how he sings the praise of reason:

"(*Reason ) is God's greatest blessing to us.... Reason is the thing without which our state would be the state of wild beasts, of children and lunatics..... Since this is its worth and place......... it behooves us not to bring it down from its high rank or in any way to degrade it... We must not give Passion the mastery over it, for Passion is the blemish of Reason.... preventing the reasonable man from finding the true guidance."*

In this book he described moral diseases and discussed how they adversely affect human behavior. He recommends that a person with moral disease should find a critic-friend who should analyze his conduct but be sympathetic to him. He recommended the maintenance of a healthy mind, for this he even prescribed spiritual cures.

Prof Hoodbhoy of Pakistan, in his book *Islam and Science*, chapter Five Great Heretics, has this to say on this aspect of al-Razi 's life.

" *Al-Razi 's unconventional views on religion certainly did not endear him with all Muslims. Later writers, though wondering at his erudition, condemned him for blasphemy because he openly spoke of the superiority of reason to revelation. Heterodox Ismailis, such as Nasr-i- Khusrow, also charged him with heresy. For his radical views, al-Razi had to pay a high price: the relegation of most of his scholarly works to oblivion. Even Al-Biruni, with the possible motive of trying to please his orthodox patron, openly denounced al-Razi and attributed his blindness to divine retribution. It is said that the blindness resulted from the punishment meted out to him by an Emir who was a member of conservative Mansur family of Bukhara. This enraged emir ordered al-Razi to be hit on the head with his book until either the book or his head broke. Thereupon al-Razi lost both his eyesight, as well as his zest for life. When an oculist suggested remedial eye surgery, al-Razi replied,* ***"I have seen enough of this world, and I do not cherish the idea of an operation for the hope of seeing more of it."***

**Commemoration**

Razi died in hometown Ray at the age of eighty-two (926) blind and in poverty. His name is commemorated in the RAZI institute near Tehran. Le Lysee Razi (Persian Dabeeristan Razi) is a high school located on Pahlavi Street, Iran. Razi University (Danish Gah Razi) is a University located in Kirmanshah, Iran. A commemorative meeting was held in London in 1913, proceedings were published "*Proceedings of 17$^{th}$ international congress of Medicine, 1913 – Lifeof Rhazes by GSA Ranking, pp 237-268*. Razi's 1000$^{th}$ year anniversary was celebrated in Paris in 1930, many scholars read their papers. One of the dissertation was titled *Arab medicine in history and its influence on France.*


Dabeeristan Razi

Razi University – Iran, 9000 students, established in 1972, it has 261 full time professors.
www. Razi.ac.ir

On the window of Princeton University chapel, NJ, there is a colorful portrait of Razi on the stained glass. I have a colored copy of this portrait, besides Razi pestel and mortar is shown, then is written bismillah al-rahman ar-raheem. Size is length 29" width 12".


Princeton University USA - chapel has the portrait of Razi on a window

In the great hall of Faculty of Medicine, Paris University, hang two portraits of Muslim physicians - Rhazes and Avicenna - as a tribute to their enormous contributions to medicine. There is scant literature available in Eastern languages on the life of this great son of Islam; however numerous books in English and German have documented his eventful life. For instance Prof Max Neuberger's book '*die Gschichte der Medizin'* published in 1911, has a chapter on his life, as well as George Ranking's book 'the Life and Works of Rhazes' published in 1913 is a good read. Another well documented book on his life is published from Iran, *Faylasuf Rayy -The Philosophers of Rayy*, by M. Mohaghegh, Tehran, 1970.

Razi and Newton

In August 2009 I borrowed a book Arabic Versions of Greek Texts from Queens University, Kingston. In the chapter what was original in Arabic sciences, the author says:" Razi's physics consisted, as far as its principles were concerned, of fundamental ideas which, given the different level of scientific knowledge, were similar to suprising extent to those of Newton's system". (Arabic versions of Greeks Texts and in Medieval sciences by S Pines,EJBrill, page 197, 1986).

That many scientific ideas of Muslims were borrowed by European scholars has been accepted as fact. An American author Jonathan Lyons says:" In an age when the modern practice of scholarly citation and other similar conventions were unheard of, it was easy for Arab ideas to be passed off as Western inventions". (*The House of Wisdom, how the Arabs transformed Western civilization, NY 2009, page 152)*

George Sarton says in his famous book Introduction to *History of Science* that " Rhazes was the greatest physician of Islam and the medieval ages." In Encyclopedia of Islam he is described as "Rhazes remained up to the 17th century the indisputable authority of medicine". The Bulletin of WHO (World Health Organization) May 1970 paid tribute to him in these words "His writings on smallpox and measles show originality and accuracy, and his essay on infectious diseases was the first scientific treatise on the subject"

His Books

Razi was very fond of acquiring knowledge and imparting the same to others. He enjoyed writing and said " *I have written in one year more than twenty thousand leaves and worked day and night for fifteen years on my book Kitab al-Hawi until my eyesight has been badly weakened and the muscles of my hand can no longer work*. "

Following books are available at Library of Congress, Washington, DC, USA: *Manafi al-Aghdhiyya wa daf madarihha, Rasail Falsafiyah, Kitab al-Murshid, Al-Sira al-Falsafiyah, Akhlaq al-Tibb, al-Mansoori fi al-Tibb, Al-Hawi fi al-Tibb, Kitab al-Ilaj al Ghoraba, Kitab al-Jadri wal Hasba (last book was translated into German in 1868 - Uber die Pocken und die Masern).*

Al-Biruni prepared a catalog of his books "*risala fee fihrist kutub Muhammad bin Zakariya al-Razi,* which was translated into Persian in 1984. The manuscript of catalog is in Leiden library. Paul Kraus translated it into French in 1936. According to catalog he produced 58 books on medicine, 7 on natural sciences, 10 on mathematics, 17 on philosophy, 14 on religions, 22 on chemistry, 6 on meta-physics and 12 on various other topics.

Other works: kitab awja'a al-mufasil naqris, kitab al-mudkhil ila-tibb, Qarabdain saghir, kitab fil tajarab, kitab birr-a'saat (cure in one hour), kalam fil Farooq bain al-amraz, kitab tibb al-malooki, kitab fib al-fuqara, risala Murshid, kitab jamay al-Kabir, kitab al-Hiss'a fee al-kulihee wal –Misana (kidney and bladder stones). Qarabdain saghir is a 14 page treatise describing compound drugs, manuscript is in Kutab Khana Aqa Hussain Malik, Iran.

Books of interest: *Jami fi al-Tibb, al-Malooki, Kitab al Qalb, Kitab al-Mafasil, Bir al-Saah, al-Taqseem aal Takhsir*. About 40 of his manuscripts are still extant in the museums and libraries of Iran, Paris, Britain, and in Rampur, & Bankipur (India). *Tibb Al-Razi* is in Arabic edited by eminent writer Muhammad Husayn Kamil, published in 1977 from Cairo. *Kitab al-Qawlanj's* (Colic treatment) French translation was published in 1983.

**Advice to patients**

Ar-razi advises patients to follow the physician's orders; *they should respect their physicians, they should consider their physicians better than their friends; they should have direct contact with their Physicians, they should not keep any secret from them, they should be in touch with them before the ailment sets in, as prevention is better than treatment*

Razi then gives the following advice to physicians. *Physicians should gain the trust of their patients, & they should be kind to all patients. Physicians should be self-reliant because knowledge gained from books is insufficient. It is said one patient suffered from irregular fever and urination. After lengthy examination Razi said that man suffered from a kidney infection, stating also that had the man told him in the beginning that he felt pressure on the lower back when standing up, he could have diagnosed it much earlier. Physician should never lose patience, he must lead a balanced life, and he should not indulge in pleasure. Physician should* give enough time to the patient; he should listen to the patient more and talk less. A physician should be proud of his profession.

*Health & Medicine in Islam, by F. Rahman, page 93, NY 1987*

**Two medical Cases**

There are many remarkable medical cases told about Razi, but the following three are of great interest. 1. A young man of Baghdad came to him complaining of haematemesis. The patient was in great despair, so Razi asked him as to the water he had been drinking during his journey. He replied that he drank water from some stagnant ponds. Razi brought two vessels filled with water-weed (Tuhlub in Arabic) which he ordered him to drink. When the patient said he could not drink any more, Razi put more in his mouth until it caused severe vomiting. Razi checked the substance that came out with vomiting, it turned out that there was a leech which was causing this trouble.

2. There was dropsical boy whose father consulted Razi in Bistam, Iran. After examination Razi declared the case to be hopeless, and advised the father to let the boy eat and drink as he pleases. (Dropsy is a condition in which large amount of fluid collects in the body tissue). Twelve months later Razi returned and found the boy to be completely healthy. Razi asked how did this come about, the father told him that one day the boy saw a snake approach a bowl of **madira** ( broth prepared with sour milk ) drink some of it, and vomit into the rest, he saw the food changed color. Hoping to end his life with this poisonous food, he ate more of it, and then fell into a deep sleep. When he awoke he was perspiring profusely, and after purging he realized he had no sign of dropsy. *(The Arabian Medicine, by EG Brown, pages 74-76, Cambridge 1921 )*

3. Razi was summoned to treat Amir Mansur who was suffering from rheumatism. Razi tried various treatments but to no avail. The Amir was in despair, Razi said to him tomorrow I will try another treatment but it will cost you the best horse and best mule in your stables. Next day Razi brought the Amir to a hot bath outside the city, entered the hot room with the patient. Razi had prepared douches of hot water and a draught which he gave to

the Amir till such time the humors in the joints were matured. Then Razi went out and came back with a knife in his hand and stood there reviling the Amir, saying things like you conspired to kill me, by sending a small boat to bring me over to you. I have decided to kill you for this, for if I don't my name is not Muhammad ibn Zakariya. The Amir became furious, and partly from anger and from fear sprang to his feet. Razi fled the bath where his horse was waiting for him, rode off to Merv. Upon arriving in Merv he sent a letter to the Amir stating that I could not treat the natural caloric, so I decided to use the **Ilaji Nafsani** (psycho-therapeutics). I provoked you to increase the natural caloric which caused you to stand up and run after me. The Amir was delighted to regain his health, and rewarded Razi with a robe of honor, a cloak, a turban, arms, a horse and two slaves and a yearly pension of 2000 gold dinars, and 200 horse-loads of corn.

Razi believed that if the body gets used to a particular drug it should be changed gradually. He also said: " if your treatment of a particular ailment using a particular drug is prolonged and still unsuccessful, change to its opposite for this is an indication that the nature of this opposite drug suits this ailment". (Kitab al-Hawi, 1955 VIII/1)

Visit the following Internet site for info on more books:

**http://www.mala.ba.ca/ ~mcneil/cit/citlrazi/htm**

Razi – a freethinker

An American author Howard Turner says: "*His was of a practical and rational mind, independent, and critical of tendency to thoughtlessly follow tradition, whether secular or religious". All men are by nature equal and equally endowed with the faculty of reason that must not be disparaged in favor of blind faith, reason enables men to perceive scientific truth in an immediate way. Razi believed in scientific and philosophical progress- the sciences progressed from generation to generation. Despite his own contributions to sciences he believed one day they would be superseded by even greater minds*". Science in Medieval Islam, page 136

Let us now see what others have said about Razi: the greatest nonconformist in the whole history of Islam, the freest thinking of the major philosophers of Islam, the least orthodox and the most iconoclastic, the single most denounced and disapproved as a heretic in the subsequent history of Islamic thought.

Gabrieli called him the greatest rationalist agnostic of middle Ages, Europe and Oriental. He was an empiricist, not at all dogmatic. His attitude was no authority was beyond criticism, though he admired Socrates, Plato, Aristotle, Hippocrates and Galen. He denied creation ex-nihilo, for him world was not created out of nothing. In his *Tibb-e-Ruhani* he not once referred to Quran or Hadith which was common at the time. He advocated moderation, shunned asceticism, and enjoined control of one's passions by reason. On life after death he did not say much, but tries to allay the fear of death by reason.

Razi did not see the possibility of reconciling philosophy and religion. In his lost book *On Prophecy*, he said reason is superior to revelation. Custom, tradition, and intellectual laziness lead men to follow their religious leaders blindly. Religions have been hostile to scientific research; they have been sole cause of bloody wars. He believed writings of Plato, Aristotle, Euclid, and Hippocrates have rendered more service to humanity. Through human reason life could be improved, not through religion. He believed sciences progressed from generation to generation. One should not reject empirical observations because they did not fit into ones preconceived scheme of things.

In his *On the Refutation of Revealed Religions*, he asked: *on what ground do you deem it necessary that God should single out certain individuals, by giving them prophecy that he should set them up above other people, that he should appoint them to be people's guides, and make people dependent upon them. How could it be possible that a God choose this method, since it invariably incites people against one another, spreads hostility, and increases fighting? The most fitting behavior of the Wise One would be to give everyone the same necessary knowledge. He should not set some individuals over others, and there should be between them neither rivalry nor disagreement which would bring them to perdition" (Jennifer Hecht, Doubt, a history, Page 227, Harper Colin NY, 2003)*

Despite his heretical tendencies he said in his Sirat al-Falasifha that man should make himself like God in the greatest degree possible. The creature nearest to God is the wisest, most just, most merciful and compassionate.

Although he was a doubter but he devoted himself to his community's well-being, and was famous for his generosity, intelligence and skill. Everyone loves & respects him to this day.

His contributions to humanity and the art of healing have been tremendous so much so that his personal and religious views have been shadowed.

His famous Sayings

Al-Razi gathered many brilliant pupils around him, who regarded him as a second Galen. His medical works have remained a handsome source of medical knowledge for generations. Following excerpts from his writings paint a brief picture of this extraordinary physician.

* “Truth in medicine is an unattainable goal and the art as described in books is far beneath the knowledge of an experienced and thoughtful physician.”

* “At the commencement of illness, choose measures whereby the strength may not be lessened. Where you cannot cure by diet, use no drugs and where simple measures suffice, use no complex ones.”

* “ Amongst those factors which make the people turn away from the physician and place their trust in impostors is the delusion that the physician knows everything and requires to ask no questions. “

* “ It is advisable for an intelligent ruler that he should not make his physician anxious, but should cheer him, be much in his society and should make it known that he will not be held onsible for the cure of incurable nor held to account for error or misunderstanding.”

* “A physician should not forget to ask his patient all sorts of questions pertaining to the possible causes of his illness, both internal and external. If a physician can treat a patient through nutrition rather than medicine he has done the best thing.”

* “A physician should always try to convince his patient of improvement and hope in the effectiveness of treatment, for the psychological state of the patient has a great effect on his physical condition.” (all of the above quotations are from History of Medicine)

* “ My love and passion for knowledge, and my labors to acquire the same, are familiar to all who have kept my company or seen me at my studies; from my youth up to this very time, I have not ceased to devote myself to this object. **If ever I have come upon a book I have not read, or heard tell of a man I have not met, I have not turned aside to any engagement**- even though it has been to my great loss- before mastering that book or learning all that man knew. So great in fact have been my endeavors and endurance, that in a single year I written as many as 20,000 pages in a script as minute as that used for amulets. I was engaged fifteen years upon my great compendium (meaning Al-Hawi) working night and day, until my sight began to fail and the nerves of my hand were paralyzed, so that at the present time I am prevented from reading and writing; even so I do not give up these occupations so far as I am able, but always enlist the help of someone to read and write for me. (Revelation *& Reason, A.J. Arberry, London, page 37&38*)

* On fearing death: “ There is no need for a man to fear death, if he be righteous and virtuous and carries out all the duties imposed upon him by the religious law which is true for this law promises him victory and repose and the attainment of everlasting bliss. “

Quotes about Razi

Rhazes was the greatest physician of Islam and the Medieval Ages."– George Sarton

"Rhazes remained up to the 17th century the indisputable authority of medicine."– The Encyclopaedia of Islam

"His writings on smallpox and measles show originality and accuracy, and his essay on infectious diseases was the first scientific treatise on the subject." – The Bulletin of the World Health Organization (May 1970)

"In today's world we tend to see scientific advance as the product of great movements, massive grant-funded projects, and larger-than-life socio-economic forces. It is easy to forget, therefore, that many contributions stemmed from the individual efforts of scholars like Rhazes. Indeed, pharmacy can trace much of its historical foundations to the singular achievements of this ninth-century Persian scholar." — Michael E. Flannery

**References:**
1. Max Neuberger, History of Medicine, English translation 1910. Available at Queens University, Kingston, Canada
2. The Spiritual Physick of Rhazes, English translation by A.J. Arberry, 1950, London
3 Will Durant, Age of Faith, history of medieval civilization 325-1300, 1950, page 247
4. John Christopher, The Islamic Tradition New York, 1972 pages 109, 121
4. Bernard Lewis, Islam and the Arab World, 1976
5. Pervez Hoodbhoy, Islam and Science by page 111, New York 1992
6. Revelation & Reason In Islam by A.J. Arberry , London, 1957, pages 37 to 39
7. E.G. Brown, The Arabian Medicine, pages 74-76, Cambridge 1921
*8.* 111 Musalman sciencedan (Urdu book 111 Muslim scientists medieval and contemporary) Nia Zamana, Publications,
Lahore By Zakaria Virk, 2013 - second edition from India, in 2 volumes published from Varanasi, India. Alizzah.universal@yahoo.com
9. Prof S.H. Nasr, Science & Civilization in Islam, 1987. I have an autographed copy of this book in my library
10. Howard Turner, Science in Medieval Islam, 1997 U of Texas, USA
11. Prof A.Y. al-Hassan, Science & Technology in Islam, UNESCO, 2001
12. Jennifer Hecht, Doubt a history, Harper Collins 2004

Chapter 6

# IBN AL-HAYTHAM – Father of Optics

**IBN A-HAITHAM** was a pioneer in several scientific and mathematical fields. He was an expert in physics, optics, astronomy, and analytical geometry. His experiments on how light is refracted by the atmosphere were later developed by Sir Isaac Newton. He discovered the law of motion centuries before Galileo Galilei. He was committed to scientific method based on observation, hypothesis and testing. He doubted the human perception and reason, which led him to search for new ways to establish the validity of observations, theories and conclusions.

Abu Ali al-Hasan ibn al-Hasan ibn al-Haythem was born in Basra, Iraq in 965. His given name al-Hasan was also his father's name. al-Haytham was his grandfather's name. When his book Kitab al-Manazir was translated into Latin, the translator's shortened his name al-Hasan to Alhacen or Alhazen. Most of his books in libraries are found under his Latin name Alhazen.

At that time the mosques served not only as a place of worship but also a center of education. Ibn al-Haytham' s education took place in one of the mosques of Basra. In the mosque a teacher would usually take up a position by a pillar while his students sat on the floor in a semi circle around him. The teacher would read from a book, deliver a lecture or pose questions to students. Classes were held by a pillar by the same teacher for many years and in some mosques names of teachers can still be seen inscribed on the pillars. Students also took part in munazarah or debates. As an adult ibn al-Haytham had participated in one of the debates. Most teachers would ask students to take notes because books were difficult to reproduce. The notes thus taken would become a book after several months which was signed by the teacher to mark the proficiency of the student, like a modern day diploma. This method of dictation was tariq-i-imla which facilitated the copies of a teachers lecture circulated among scholars. Religion, literature, grammar and rhetoric were taught in the mosques. Ibn al-Haytham studied theology in his youth which meant reading and understanding the meaning of the Quran and Hadith.

### Life in Basra

During ibn al-Haytham's life Basra had grown from a small military post to a busy port city filled with variety of cultures. Small communities of Africans, Indians, Persians and Malays flourished in the city. Scholars on their way to the Baytul Hikma (Science Academy) in Baghdad often stayed in the city as guests of patrons of learning.

Ibn al-Haytham started the study of philosophy by reading works of Aristotle. After reading one book he would write a summary so others won't have to read the entire book. When he turned 63 he had written summaries of 13 books of Aristotle.

Then he began commenting on some of the books. A leader of the Mutazilah sect Abu Hashim had criticised one of Aristotle's book, he wrote a defence for it. Yahya Nahhavi had criticised Aristotle's views on the nature of cosmos, ibn al-Haytham wrote a treatise on this topic.

When he started the study of mathematics, he discovered that he had a gift for mathematics. He started his studies by reading the works of Euclid whose famous book Elements was the best introduction to geometry. As before he summarised and condensed the book. He wrote in his biography: "I have taken Euclid as a guide with regard to geometrical and numerical laws. I have solved various problems and have explained the numerical problems by means of equations. I have also deviated from the postures adopted by the previous exponents of algebra."

Then he delved into the works of Archimedes who was born in Sicily. He had grouped angles into three basic kinds. Ibn al-Haytham wrote a commentary on this criticizing the logic on which Archimedes had based his conclusions. He also studied works of Ptolemy. Ptolemy had trigonometry in his famous astronomical book Almagest. Al-Haytham produced a summary of it and commented on it also. He was not satisfied with the commentary, he wrote: "If I am vouchsafed a longer life by the grace of God, I shall write another commentary which shall embody the algebraic and other mathematical disciplines thoroughly."

Ibn al-Haytham was appointed to a government job in Basra but he feared that this provide little time for to study philosophy and mathematics. But this was necessary so he could support his family. Some historians have written that Ibn al-Haytham worked in the finance department as he wrote a book entitled *On Business Arithmetic*. Some believe that he was a civil engineer, who supervised building of roads, bridges and buildings. He wrote several books on civil engineering such as: *Determination of the Altitudes of Mountains, Determination of the Height of the Pole with the greatest precision, On the altitudes of Triangles, On the principle of Measurement.* He wrote a book *On The Construction of the Water Clock*, which would be large machinery placed near the gate of a mosque. This book shows his fascination with hydrodynamics, the motion of fluids. He also produced a book on canals and dams.

According to a 12$^{th}$ century historian al-Bayhaqi, ibn al-Haytham wrote: a book on civil engineering in which he discussed the possibility of offsetting the shortages of water in the Nile. Another historian Ibn abi-Usaybah wrote that ibn al-Haytham thought of building a system of dams, levees, and canals that would prevent Nile from overflowing in the fall and preserve its water for irrigation during the dry summer season.

His government job was keeping him away from his pure love of learning mathematics and philosophy. In order to escape his duties he pretended to be insane. Consequently he was relieved of his duties. In his autobiography he wrote: "*I am not aware of the feelings, thoughts, and sensations which have guided me since my childhood, call it what you may – a matter of chance, or intuition vouchsafed by God, or madness. You may attribute the source of my inspiration to any of the three.* " Possibly he claimed to be insane to make himself inspired.

Ibn Al-Haytham comes across as a very humble person in his books, giving credit to others where it was due. A few years after he had left his government job, he showed signs of mental sickness. Mental sickness was difficult to cure at that time or its proper diagnosis the way it is now.
However his writings at this time of his life show no sing mental instability. Whether he was faking his sickness or it was real, he pursued the study of mathematics, geometry and philosophy.

At his juncture of his life a strange thing happened. In 1010 a visitor showed up at his doorstep with a message from Caliph al-Hakim be-amr Allah, ruler of Egypt. The Caliph wanted to discuss with him the subject of taming the Nile to control floods. could not decline this offer.

## Life in Cairo

Caliph al-Hakim (997-1020) was a wealthy leader who prized learning. He had built an academy of science (Dar ak-Ilm) in Cairo and had patronized scientist like Ibn Yunus. He built several mosques, and was considered a descendant of the Prophet Muhammad. Al-Hakim was a strange leader who once ordered that all dogs in Cairo should be slaughtered because their barking annoyed him. During his reign, he persecuted Sunni Muslims, Jews and Christians. He had many of his ministers murdered. In the morning he would issue one order, in the evening he would renege. He ordered cobblers not to make any shoes for women. He ordered that businesses should be closed during the day and open in the night. For this he was called 'the mad Caliph.'

Al-Bayhaqi, who died 30 years after ibn al-Haytham did, relates that after arriving in Cairo he stayed in an inn. One day he was told that al-Hakim was waiting for him outside the gate of the inn. He presented the Caliph his treatise on building a dam on the Nile. When ibn al-Haytham finished explaining his plan, the Caliph said to him: Your are wrong, the expenses like to be incurred on the project are in excess of the gains. However al-Hakim pledged to give the Iraqi scholar all the workers to complete the project.

Ibn al-Haytham travelled 600 hundred miles to the village of al-Janadil, near Aswan where he had proposed to build the dam. He found al-Janadil an ideal place to build the dam. He realized that if workers could block the north end of the channel with a stone dam, the water would not be able to flow around it. Held in by the granite banks, the water would rise behind the dam, forming a lake. However when he measured the opening between the banks, he found that opening was 3200 feet wide at ground level, the river itself was only 1800 feet. He realised that scope of the project far exceeded the resources at his command. Nine hundred years after al-Haytham had surveyed the site, the Egyptian government built a dam on the very spot he had proposed. Builders used 58 million cubic yards of material to construct Aswan High Dam.

Ibn al-Haytham travelled back to Cairo and admitted to Caliph al-Hakim that his plan would not work. The Caliph placed him under house arrest, confining him to a single room, and took away his possessions. Striped of his possessions, he could neither write nor read, but his mind was not dormant. Prisoners are known to do amazing things, some writing poems, books and committing books to memory. Some have scratched writings and drawings into the walls of their cells. It is possible his confinement may have led to major breakthroughs in his scholastic career.

### His outstanding work

*The Book of Optics* is ibn al-Haytham's major scientific work. In this book he corrected misconceptions about vision and light. For instance ancient Greeks believed that human eyes sent out rays that sensed objects. He showed that opposite was true: vision occurs when rays of light enter the eye and stimulate the optic nerve. He also created unified theory of light, describing its propagation, reflection and refraction. This book was a leading source on optics for next 700 years.

The beauty of this book lies in the fact the discoveries he made and how arrived and supported these. He was the first person to construct devices – such as camera obscura – to test hypotheses and verify the accuracy of his findings. In this way he established the modern scientific method. In the book he described dozens of experiments which one person could perform. The objects used in the experiments are bare walls, stopped up windows, screens, lamps and tubes. One gets the impression the whole books was composed in an empty room, and perhaps world's first *camera obscura* was a prison cell in Cairo.

The first device used for projecting an image onto a flat surface was known in Europe as *camera obscura*. Camera means a room and obscura means darkened room with a small opening (aperture) that allowed light to shine on a wall. The light on the surface formed a color image, upside down and backwards – of whatever was outside the room, across from the aperture. This was described in *Kitab al-Manazir*. Later on a camera was made on this principle.

### Nature of light

Ibn al-Haytham supported all his assertions with experimental or mathematical proofs. For he wrote "*straight lines exist between the surface of the eye and each point on the seen surface of the object. An accurate experimental examination of this fact may be easily made with the help of reulers and tubes*". The most important discovery in the Book of Optics is: Sight does not perceive any visible object unless there exists in the object some light, which the object possesses of itself or which radiates upon it from another object". With this observation, he solved the mystery of vision that had baffled scientists for centuries. It was light rays that travelled from visible objects to the eye. He realised that vision and light were linked that is why a significant portion of kitab al-Manazir is devoted to the study of light.

He divided light into two basic groups, primary light and secondary light. Primary light is the light radiated by an illuminating body, such as a lamp, the stars or the sun. Secondary light is primary light that has been reflected off another object. During the day sun provides primary light, and a bird, a tree, a stone, a blade of grass – reflects the light of the sun. Even the atmosphere reflects light, which is why the sky brightens even the before sun rises. All light travels in rays, originating at a single point and moving in a straight line away from that point. Light radiates in all directions from its source.

### Scientific method

His method of inquiry was unique. He would begin by stating the problem: Do light rays affect each other when they intersect? Next he gathers information by observing how light behaves in various circumstances. Based on these observations, he offers a possible answer, or hypothesis:

Light rays are able to intersect without being affected by each other. He then constructs a simple experiment to test this hypothesis, forcing the lights from different lamps to cross at a single point. After repeating his experiment and confirming his results, he finds that the evidence supports his hypothesis. This systematic, step-by-step approach, based on both sound logic and observed fact, would come to be known as the scientific method. It is the method of inquiry that scientists around the world continue to use, to this day.

His masterpiece on the science of optics was into 7 books. **Book 1** is manner of vision generally, and a chapter on structure of the eye. He described parts of the eye in graphical detail. He correctly explained how the cornea refracts, or bends, light rays as they enter the eye. He also suggests that the optic nerve carries visual sensations to the brain. He was the first scientist to maintain that vision occurs in the brain, not in the eye. Thus he pioneered the psychology of visual perception. He argued that personal experience affects how and what people see. He was fascinated by errors of vision that is why he devoted **Book III** to this topic. He was aware that vision and perception are more subjective than most people allow-for this reason he had faith in scientific inquiry.

He was fascinated by the effects that flat and curved mirrors have on light. He devoted Book **IV** to reflection from smooth bodies. **Book V** to "the forms seen inside smooth bodies". This section of the book contains one of the most enduring problems posed by ancient mathematics. He imagined a scenario involving an observer, a light source, and a spherical mirror, all three in fixed locations. The observer looks upon the spherical mirror, which reflects the light from the light source. He tried to determine the point on the spherical mirror where the light is reflected to the eye of the observer. It is known as Al-Hazen Problem". He solved this problem using geometric proof, but an algebraic solution to the problem eluded mathematicians until the end of the 20th century.

**Book VI** to "errors in sight in what it perceives by reflection". He was interested in the way that transparent object such as water and glass, refract light. **Book VII** to "the manner of visual perception by refraction through transparent bodies." If all four of these books, he uses high-level geometry and mathematics to explain the behaviour of light.

Despite its brilliance, Kitab al-Manazir is not free from errors. His greatest error was his failure to understand the eye works like a small camera obscura, with the pupil acting as an aperture that projects a small image – upside down and backwards – onto the retina. This discovery was made 600 years later by Johannes Kepler who accurately described how an image forms within the eye. Kepler did this by using scientific method.

**Life as a scholar**

For 10 years Ibn al-Haytham remained under house arrest in Cairo. Whether he spent this time recovering from mental illness or simply languishing in the jail cell, or worked on his books in not known. What is known is on the night of February 13, 1021 Caliph al Hakim bi-amr Allah went for a walk in the Muqattam Hills and never returned. The mad Caliph simply vanished. Ibn al-Haytham was informed of this development by government officials, his possessions restored to him and released from jail. With no money, he made his way to the Azhar mosque where he was allowed to take up residence in a domed room by the gate of the mosque.

Ibn al-Haytham supported himself by copying manuscripts of Ptolemy's *Almagest*, Euclid's *Elements*, and *intermediate books*, a collection of works on astronomy and mathematics that included Euclid's Data, Optics and Phenomena. He charged "the non-negotiable price" of 150 dinars. He lived on the sale of one set of these books each year. He may have copied other books as well. The Ayasofa Library in Istanbul, has in its collection an Arabic translation of Apollonius's *Conics* that was copies and signed by Ibn al-Haytham.

It appears that he taught in Cairo also. Ibn abi Usaybiah reports that an Egyptian scholar Mubashir ibn Fatik studies mathematics and astronomy with ibn al-Haytham. A Syrian nobleman Surkhab came to ibn al-Haytham and asked if he could study with him. Ibn al-Haytham agreed to tutor him but demanded 100 hundred dinars a month for payment. Even though the price was high, Surkhab agreed to pay. For 3 years Surkhab studied with ibn al-Haytham. At the end of his education, Surkhab bid his turor farewell. Ibn al-Haytham asked him to wait a moment, returning all 3,600 dinars to Surkhab. " *I just wished to test your sincerity and , when I saw that for the sake of learning you cared little for the money, I devoted full attention to your education. But remember, in any righteous cause, it is not good to accept a return, a bribe, or a gift*". Ibn al-Haytham said.

The Amir al-Umara of Syria offered ibn al-Haytham a large sum of money to work as a scholar in his court. Ibn al-Haytham agreed but not at the price offered. "All I need is my daily food, a servant, and maid to look after me. If I amass more than the bare minimum that I need, I shall turn into your slave, and If I spent what I save, I shall be held liable for wasting your wealth", ibn al-Haytham told the leader.

When he was not teaching or copying manuscripts, he wrote Maqala fi-al shukuk ala Batlymus – Doubts concerning Ptolemy. He pointed out a contradiction between the explanations in Ptolemy's two books about how the atmosphere refracts the light of stars. He also criticized Ptolemy's discussions of optical illusions, convex mirrors and refraction. According to ibn abi-Usaybiah list, he may have written 182 treatises after his release in 1021. List I covers a period up to February 10, 1027 containing a total of 69 works- 25 on mathematics and 44 on philosophy and physics. List II which is also Ibn al-Haytham's own handwriting, covers the period February 11, 1027 to July 25, 1028. During these 18 months, he composed another 21 works, covering a wide range of subjects, philosophy, physics, theology, medicine, optics and astronomy. Third list contains 92 works, these cover optics, mathematics, astronomy, music, poetry, logic, and ethics.

List III contains *The Books of Optics*, as well as 12 more works on light and vision. In one of these, *Discourse on Light*, he summarized the sections on light from Book of Optics. In *Treatise on the Form of Eclipse,* he used the camera obscura to observe "the form of the sun's light". In doing so, he offers a correct explanation of how light traveling through an aperture becomes focused on an opaque body, such as a screen or a wall.

His interest in refraction led him to discuss how light behaves in the atmosphere in Treatise on the Rainbow and the Halo. He also explored the behaviour of light in his astronomical works such as: Treatise on the Appearance of Stars, Treatise on the Lights of the Stars, Treatise on what appears of the difference in the heights of the Stars, Treatise on the light of the Moon.

His fascination with reflection led him to write several more treatises on curved surfaces, Treatise on Burning spheres, Treatise on Spherical Burning Mirrors, and Treatise on Parabolic Burning Mirrors.

**Books on astronomy**

Ibn al-Haytham wrote several books about astronomy. One of these, *On the configurations of the World*, - Kitab Hai'tu al-Alam - is his most famous book. He begins by stating that earlier astronomers such as Ptolemy, had carefully recorded

" the circumstances of the heavenly bodies, their relative ordering, their distances from each other, the magnitude of their bodies, their various positions, the kinds of their motions and the varieties of their shapes". These records and calculations were used to predict the positions of heavenly bodies, but they did not explain what the celestial bodies were or how they moved through the heavens. They were "based upon the motions of imaginary points on the circumferences of intellectual circles. " Ptolemy had proposed what is known as an epicycle system, wherein the planets follow a small orbit called epicycle that in turn orbits a larger sphere called a deferent. Ibn a-Haytham was not satisfied with an abstract picture of the world. The planets and stars are real things, he argued, and any theory of their movements must take this into account.

For ibn-al-Haytham it was vital that the spheres move in a simple, consistent manner. Anything more complicated would violate the laws of nature, as well as logic. For instance, to explain his observations of Mercury and Venus, Ptolemy had suggested that the two planets oscillated, or moved back and forth. Ibn al-Haytham said this violated common sense as well as Ptolemy's earlier statements about the motion of heavenly bodies. He wanted to describe a system in which all of the heavenly bodes move without any hindrance. Rather their motions are continuous. He pictured a set of spheres, called orbs, nested within each other. Each orb contains a heavenly body. The nearest orb contained the moon. He described the motions of all of the orbs in precise geometric terms. Despite the elegance of this system, ibn al-Haytham was wrong. The sun, planets, and stars do not revolve around the earth. Rather the earth and the planets revolve around the sun, and the sun revolves around the center of the Milky way galaxy.

Kitab Hai't al-Alam set a new standard for astronomy despite some errors. Movements of the heavenly bodies could no longer be described by imaginary points and circles. His insistence that observational data be linked to a realistic planetary scheme anticipated the accomplishments of later astronomers like Copernicus, Galileo and Kepler.

The title of one of his later treatises offers a clue about the last years of his life. *A Reply to a geometrical question which I was asked at Baghdad in the Year* 418AH (1027-1028). This explains that he was in Baghdad six years after the death of Caliph al-Hakim. The title of another book " *Replies to seven mathematical questions addressed to me in Baghdad*" suggests that he visited Baghdad before 1027 as well while living in Basra.

**Last years of his life**

Ibn al-Qifti says ibn al-Haytham spent the last 20 years of his life in Cairo and died there in 1041. It was not unusual for scholars to travel different cities to participate in *munazarah*. There exists an oldest surviving manuscript of The Book of Optics, whose copyist was Ahmad ibn Jafar al-Askari, son in law of ibn al-Haytham. Askari says he copied Kitab al-Manazir in 1082, forty one years after ibn al-Haytham's died. Historian al-Bayhaqi says that ibn al-Haytham developed a persistent case of diarrhea, despite intense pain, he clung to life for seven days. Feeling his life ebbing away, he turned towards kaaba and recited a verse from the Holy Quran " Verily we are from Allah, and to Him shall we all return". With these words, the greatest scientist of the middle ages, left the world he had worked to understand. His life was over but the revolution he had founded has scarcely begun.

**His masterpiece**

The Book of Optics was translated into Latin in late 12th or early 13th century. Ibn abi Usaybiah says that he wrote 182 books and treatises. About 62 works are known to have survived to the present day. His other works may have been destroyed deliberately as religious leaders looked upon science with suspicion. Mathematics and natural sciences were not taught in the mosques when ibn al-Haytham was a student. His works circulated throughout the Arabic speaking world, into areas controlled by many different sects. Attitudes toward philosophy and science varied from city to city. According to famous Jewish philosopher Moses ibn Maimonides who died in Egypt in 1204, the suppression of philosophical works was underway in Baghdad by the beginning of 13th century. One historian wrote that he saw Baghdad officials burn the library of a philosopher who had died in 1214. Some of ibn al-Haytham's wroks met the same fate.

In the 13th century religious leaders began to employ a person to calculate the times of five daily prayers each day. The person who performed these calculations was known as the *Muwaqqit*, from the Arabic word, Waqt, which means "definite time". The *muwaqqit* had to be both an astronomer and a mathematician. Some muwaqqit, such as Ibn al-Shatir went beyond their normal duties to make new discoveries.

As the interest in pure science wanted in the Muslim world, the opposite was happening in the Europe. As in the Muslim world, most education in Christendom took place in the churches and centered on religious thought. Christianity greatest thinkers were theologians and philosophers. By 12th century Christian scholars were broadening their interests including science. In Islamic Spain an astrosphere of tolerance prevailed, making Spain a vibrant center of learning. In Toledo, Cordoba and other cities, Muslim, Jewish, and Christian scholars exchanged views and shared information. Through the Muslims, European scholars came into contact with ancient Greek scholars which had been preserved in Arabic translations. They came to know Muslim scholars such as Khwarizmi, al-Kindi and ibn al-Haytham.

Word of the Muslim libraries spread beyond the borders of Spain. In the 12th century, for example, an Italian Gerard of Cremona wanted to read Ptolemy's Almagest which was not available in Latin for centuries. Gerard heard that an Arabic translation of this book was available in Toledo. Gerard traveled to Toledo, learned Arabic, and read the book. He discovered works by other Greeks that also had been translated into Arabic. Rather returning to Italy, he stayed in Spain and began translating Arabic books into Latin. He translated books by Aristotle, Euclid, and Galen, and ibn Sina. He soon realised he could not do the work alone, so he recruited other scholars to translated treasures of Muslim learning. He and his associates translated more than 80 books, one of which was ibn al-Haytham's *On Parabolic Burning Mirrors*. Kitab al-Manazir was translated into Latin as *De Aspectibus*, or *the Optics*, and the author was Alhacen, a Latinized form of al-Hasan. Kitab al-Manazir does not contain any reference to other thinkers or scholars, all his conclusions were based on experimentation, observation, mathematics and deduction.

His books burnt in Spain

In the year 1192, al-Hakim Yusuf al-Sabti watched as an angry mob burned down the library of a great doctor from Cordoba, who had been accused of atheism by the clerics of Baghdad. He saw in the hands of Sheikh Ibn al-Maristaniya, the leader of the mob, a rare copy of the *Tadhkirah fi'Ilm al-Haya'a*, a masterwork by the great medieval scientist Abu Ali ibn al-Haytham that contained proofs that the earth was round. Al-Sabti recorded: "The sheikh exclaimed: 'here is a huge disaster', and as he said that he ripped up the book and threw it into the fire." The heirs of the medieval Islamic rulers who had been al-Haytham's patrons did not resist the tide: with no challenge to their power then in sight, science was a small sacrifice to appease increasingly powerful clerics.

In the centuries that followed, the Middle East's intellectuals plunged into what the Germans call *kadavergehorsamkeit*: the silence of corpses. The historian Abdur Rahman ibn Khaldun could even assert that Ilm al-Kalam, or intensive logical reasoning, was no longer "necessary in this era for the student of knowledge, since apostasy and heresy have become extinct".

Al-Haytham's work was rediscovered in Renaissance Europe, though; his breakthroughs on astronomy, mathematics, and optics and, above all, the scientific method, helped lay the foundations for the continent's long ascendancy.

**Influence on Europe**

Medieval European scholars were impressed with detailed account of anatomy of the eye given in *Kitab al-Manazir*, as well as novel ideas about vision, description of many experiments that any one could duplicate. It became one of the most copied works of medieval Muslim science.

Instead of translating the book, the translator often paraphrased the author. Such sections are misleading. The translator also condensed the book by leaving out whole passages, even omitted first 3 chapters of Book I containing vital information like his description of two earlier theories of vision, his conclusions about the nature and properties of light, his thoughts about the achieving certainty in matters of science, his method of enquiry. Despite this many of his ideas came through to Europeans scholars. Because he often alluded to earlier parts of the book, some of the conclusions contained in 3 chapters of Book I were mentioned later.

One of the first medieval scholars to read and respond to this masterpiece was a Monk from UK Roger Bacon. One of the books in his collection was *De Aspectibus (Kitab al-Manazir)*. He wrote a book on optics entitle *Perspectiva*, based entirely on ibn al-Haytham's work. He accepted ibn al-Haytham's theories about light and repeated some of his experiments, including the one
about camera obscura. He endorsed ibn al-Haytham's method of inquiry.

Although Bacon acknowledged his gratitude to ibn al-Haytham in the field of optics, but he did not give him credit for having developed the method of inquiry. The reason may be that Christians and Muslims were fighting for control of Jerusalem in a series of wars called Crusades. Bacon was a member of clergy; he may have felt that attaching a Muslim scholar's name to scientific method would slow its acceptance among Christians.

Another clergyman who was impressed with Kitab al-Manazir was **John Pecham** who was born around 1230. He was so inspired by the Latin translation of this book that he decided to summarize it, much as Ibn al-Haytham had summarized the works of Ptolemy and Euclid. Pecham's book *Perspectiva Communis* refers to ibn al-Haytham as "the Author" or "the Physicist". Another European scholar **Witelo**, a friar of Roman Catholic Church who attended college in Padua around 1260, expanded on *Kitabl al-Manazir*. He was so impressed with Kitab al-Manazir that he decided to write his own books on optics. The structure of his book was identical to Kitab al-Manazir, so was the content. Through Pecham and Witelo, ibn al-Haytham's ideas spread throughout Europe.

Scholars continued to read ibn al-Haytham's work independent of commentators. At the beginning of 14$^{th}$ century Kitab al-Manazir was translated into Italian, which made his discoveries available to people in trades and business. Many have scholars have suggested that Dutch painters

**Book on Astronomy**

Next to book of Optics, Ibn al-Haytham's most important work was Kitab Hai'tul Alam (On the configuration of the world). In this book he shows his lifelong commitment to "*concepts whose matter are sensible things*". He begins by stating that earlier astronomers like Ptolemy had recorded "the circumstances of the heavenly bodies, heir relative ordering, their distances from each other, the magnitude of their bodies, their various positions, the kinds of their motions and varieties of their shapes". These records predicted the positions of the celestial bodies, but did not explain what these celestial bodies were or how they moved through the heavens. Ptolemy had proposed the epicyclical system in which the planets follow a small orbit called an epicycle that in turn orbits a larger sphere called a deferent. Ibn al-Haytham was not satisfied with an imaginary picture of the universe. The stars and planets are real things, any theory of their movement must take this into account. He raised similar questions in his book *Doubts concerning Ptolemy*.

Ibn al-Haytham believed that an explanation was needed how real, physical bodies move through the sky. Therefore he set about the task of explaining "*each of the motions which he(Ptolemy) mentoned in such a manner that that motion may appear to be the result of a spherical body that is moving with a simple, continuous and unceasing motion".*

It was vital that the spheres move in a simple, consistent manner. He argued. Anymore
More complicated would violate the laws of nature, as well as logic. For example Ptolemy has suggested that Mercury and Venus moved back and forth. Ibn al-Haytham wrote this explanation violated common sense, *" this is utter nonsense and contradicts his previous doctrine that the heavenly motions are equal, continuous and unceasing. For it is impossible that anything but a body move with this motion, for only existing bodies can have sensible motions*". His goal was to describe a system in which all of the heavenly bodies move without any hindrance, or impediment.
He pictured a set of spheres, called orbs, nested within each other. "*The shape of the world in its entirety is the shape of a sphere*". Each orb contains a heavenly body. The nearest orb contained the moon, there were orbs containing Mercury, Venus, the sun, Mars, Jupiter, Saturn and finally the stars. He described the motions of all of the orbs in précised geometric terms.

Despite the elegance of the system, ibn al-Haytham was wrong to suggest that the sun and planets and stars revolve around the earth. Rather, as we now know, the earth and the planets revolve around the sun, the sun revolves around the Milky Way galaxy. The paths they travel across the sky are shaped by the invisible force of gravity, not attached to physical centres as he had thought.

Despite some of the erros, Kitab al-Hai'at set a new standard for astronomy. Astronomers no longer could describe movements of heavenly bodies with imaginary points and circles. Ibn al-Haytham's insistence that observational data be linked to realistic planetary scheme anticipated the accomplishments of later astronomers like Copernicus, Galileo and Kepler.

A title of his book A reply to geometrical question which he was asked at Baghdad in the year 418 AH (1027-28) suggests that he was in Baghdad six years after the death of Caliph al-Hakim. However according to al-Qifti, ibn al-Haytham spent the last 20 years of his life in Cairo and died there in 1041. His visits to Baghdad were brief. It would not have been unusual for a scholar like him to travel to various cities to engage in munazarah. However, it seems strange that he would have travelled between cairo and Baghdad – a distance of 900 miles – when he was over 60. In any event he spent his last years unmarried in cairo where he developed a persistence case of diarrhea. Despite intense pain, he clung to life for seven long days. Finally he turned towards Kaaba and recited" verily my return is to thee, I rely upon thee and turn unti Thee". With these words the greatest sciencist of the middle ages left the world he had worked so hard to understand and to explain to others. His life was over, but the revolution he founded had scarcely begun.

The Physicist

Kitab al-Manazir was translated into Latin in the late 12th century, but identity of the translator is unknown. According to ibn abi-Usaybiah he wrote 182 books and treatises. In his autobiography he wrote that several more of his works had "fallen into the hands of certain people in Basra and Ahwaz, the manuscripts of which have been lost". About 62 works are known to have survived to the present day. In 1572 a Swiss publisher Fredrick Risner published *De Aspectibus* and Wilelo's *Perspectiva* in one volume called *Opticae Thesaurus*. Through this volume thousands of scholars across Europe became familiar with Ibn al-Haytham's ideas and methods. This is the period Europe going through the period of Renaissance. Many schoalars in many fields made great advances. For example, in 1543 Copernicus proposed the theory that the earth rotated on its own axis every 24 hours and it revolved around the sun. In 1572 Tycho Brahe observed the birth of a new star in the constellation Cassiopeia, a finding that challenged the belief that the stars were fixed in the sky. As scientific learning increased, so did appreciation of ibn al-Haytham's work.
For the first time Europeans scholars had the skills to fully appreciate the higher mathematics contained in The Book of Optics. Several 17th century mathematicians like Fermat (France), Harriot (England), Beeckman & Willebrod Snell (Netherlands) referred to Alhazen by name in their works.

Kepler used Alhazen's own method to disprove his theories about vision. He proved through an experiment that the eye works like a *camera obscura*, with the pupil serving as an aperture and the retina as the receiving screen. The optic nerve carries the image from the retina to the brain, which inverts the image so that it perceives objects right side up.

For six hundred years Alhazen remained leading authority in many fields. By the middle of 17th century European scientists had refined and expanded and surpassed his discoveries. For example Rene Descartes, who had read Kitab al-Manazir, published 3 essays- Dioptrics, Meteorlogy and Geometry – that expanded on Alhazen's discoveries regarding refraction, the rainbow and analytic geometry. The Dutch physicist Christian Huygens also read Alhaze masterpiece and answered many of its unsolved questions.

When Polish astronomer Johannes Hevelius published a detailed description of the moon's surface in 1647, the publisher hired an artist to design an illustration for the cover of the book. The engraving shows two standing figures holding a large scroll bearing the title of the book Selenographia. One of the figures is Galileo holding a telescope, s symbol of observation. The other figure is ibn al-Haytham holding a geometrical drawing, a symbol of mathematical proof. The two objects they hold represent two steps of scientific method that both men pioneered.

Four years after Havelius had honored Alhazen on the cover of his lunar atlas; another scientist went a step further and put his name on the map of the moon. Riccioli published a book Almagestum Novum that included few maps of the lunar surface, about 15 degree north of the Moon's equator, the circular impact crater about 30 km wide named Alhazen. In 1935 International Astronomical Union standardized the names of 60o lunar features, including the crater Riccioli had named for ibn al-Haytham.

**1000th anniversary**

With the passage of time, Alhazen's name and achievements faded into history but around the beginning of 20th century scholars like Brockleman, H. Suter, and E. Wiedemann – all from Germany- travelled to Istanbul and other centres of Islamic learning unearth long forgotten works of Alhazen. In 1936 Max Krause, another german scholar, published a list of manuscripts of *Kitab al-Manazir* that included a reference to the manuscript that had been copied by his on-in-law ibn Jafa'ar al-Askari. Since then the scholars have translated the complete Kitab al-Manazir – including the 3 chapters missing from the Latin translation, into major European languages. Many of his other works have also been translated in European languages. For the first time scholars are appreciating the breadth of his knowledge.

When Napolean Bonaparte occupied Egypt in 1798, Muslim scholars began to fully appreciate how far behind the Europeans they had fallen. "Our country must changes its ways and news sciences must be introduced", declared Shaikh Hasan al-Attar, after examining the technology the French had brought to cairo. When Muhammad Ali became the viceroy of Egypt in 1805, he began to modernize the Egyptian education. In 1836 he proposed an educational mission to france which was led by Rafi al-Tahtawi. Upon his return from Europe, Tahtawi became the director of School of Languages, an institution devoted to the translation and study of scientific works. As Muslims students and teachers absorbed the lessons of European science, they came to appreciate the role Muslim scholars such as ibn al-Haytham had played in the scientific revolution of the Renaissance.

As the 1000 anniversary of Ibn al-Haytham's birth approached, scholars around the world prepared to honour one of the foremost founders of modern science. Pakistan issued a special stamp commemorating ibn al-Haytham as the "father of optics". In 1969 the Hamdard National foundation, sponsored a celebration of the 1000th anniversary. Scientists and historians delivered papers and discussed Iraqi scholars's legacy at the University of Karachi.

In 1971 Qatar issued a postage stamp honouring ibn al-Haytham honouring "famous of Islam" series. In Jordan a hospital was named after the Iraqi scholar. Not far from where ibn al-Haytham took part in a *munazarah* stands the ibn-al-Haytham college of education, part of university of Baghdad. Children in central Baghdad attend ibn al-Haytham elementary school, while boys in Nablus, (Palestine) attend the ibn al-Haytham elementary school for boys. On April 14, 1992 former president of Iraq Saddam Hussein established *the ibn al-Haytham Missile Research* and Design Center, dedicated to the development of ballistic missiles.

Ibn al-Haytham has been featured on Iraqi currency at various times in history. In 1931 the government of Iraq began issuing a new banknote, the dinar, to replace the Indian rupee as the official currency of Iraq. The new banknotes featured images of Iraqi landmarks and historical figures, including ibn al-Haytham. After the first Persian Gulf war in 1991, ibn al-Haytham image was on the 1 dinar note. On October 15, 2003 Central Bank of Iraq decided to decorate the face of 10,000-dinar note – with a portrait of ibn al-Haytham as a symbol of progress and achievement.

Ibn al-Haytham had written in Doubts concerning Ptolemy,

> ***Truth is sought for itself, but the truths are immersed in uncertainties, and scientific authorities are not immune from error, nor in human nature itself. The seeker after truth is notone who studies the writings of the ancients and following his natural disposition, puts his trust in them, rather one who suspects his faith in them and questions what he gathers from them, the one who submits to arguments and demonstrations, and no to the sayings of a human being whose nature is fraught with all kinds of imperfections and deficiency. Thus the job of the man who investigates the writings of scientists, if learning the truth is his goal, is to make himself an enemy of all that he reads, and applying his mind to the core and margins of its content, attack it from every side. He should also suspect himself as he performs his critical examination of it, so that he may avoid falling into either prejudice or leniency. "***

References:

1. al-Haytham – first scientist, by Bradley Steffens, Morgan Reynolds Publishing, Greensboro, North Carolina, 2007 `

2. Ibn al-Haytham, the optics of ibn al-Haytham. Translated by A.I. Sabra, The Warburg Institute.
3.Proceedings of the Celebrations of 1000th anniversary, edited H.K. Said, The Times Press, Sadar, Karachi, 1969 – article Ibn al-Haytham and his Philosophhy, by Dr Naseer ahmad Nasir.
4.Saleh Beshara Omar, ibn al-Haytham's optics. Bibliotheca Islamica, 1977 Minneapolis. USA
5.A.I. Sabra, Introduction to the Optics of ibn al-Haytham.
6.Y. Tzvi Langermann, Garland Publishing, 1990 – translation of "On the configurations of the worlds".
7.A.I. Sabra – Optics, astronomy and logic: studies in Arabic science and Philosophy, Brookfield, Vermont, Variourum, 1994.
8.A.I. Sabra – Science and technology in the Eastern Arab countries, Haskin Press, Princeton, 1965

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Chapter 7

# Medical Breakthroughs in Islamic Medicine

Physicians occupied a high social position in the Arab and Persian culture. Prominent physicians served as ministers or judges of the government, were community leaders and were appointed royal physicians. They were considered expounders of philosophy, and the sciences. Physicians were versed in logic, philosophy and natural sciences. All of the prominent Muslim philosophers earned their livelihood through the practice of medicine.

In this article we will narrate some of the astounding medical breakthroughs made by Muslim physicians including the fields of allergy, anatomy, bacteriology, botany, dentistry, embryology, environmentalism, etiology, immunology, microbiology, obstetrics, ophthalmology, pathology, pediatrics, psychiatry, psychology, surgery, therapy, urology, zoology, and the pharmaceutical sciences.

Muslim World`s greatest contribution to the world was in Islamic medicine. The Islamic scholars gathered vast amounts of information, from around the known world, adding their own observations and developing techniques and procedures that would form the basis of modern medicine. In the history of medicine, Islamic medicine stands out as the period of greatest advance, certainly before the technology of the 20th century.

In this article we will present astounding medical breakthroughs made by 7 Muslim physicians only. However I am cognizant of the fact there were other physicians who were trailblazers in the field of medicine as well.

**(1) Yaqoob al-Kindi (801-873)**

Yaqoob al-Kindi (801-873), in his most important work on medicine *De Gradibus*, demonstrated the application of mathematics and quantification to medicine, particularly in the field of pharmacology. This includes the development of a mathematical scale to quantify the strength of drugs, and a system that would allow a doctor to determine in advance the most critical days of a patient's illness, based on the phases of the moon. In his *Treatise on Diseases Caused by Phlegm*, he provided the first scientific explanation and treatment for epilepsy. He was the first to use the method of experiment in psychology, which led to his discovery that sensation is proportionate to the stimulus. He was also the earliest to realize the therapeutic value of music and attempted to cure a quadriplegic boy using music therapy.

In his *Aqrabadain* (*Medical Formulary*), he described many preparations drawn from plant, animal and mineral sources.

To the drugs known to physicians such as Hippocrates and Galen, Kindi added knowledge drawn from India, Persia and Egypt. Like many Islamic works, the books contained information based upon medicinal herbs, aromatic compounds, such as musk, and inorganic medicines. Islamic contribution to the history of medicine saw the first divide between medicine and pharmacology as separate sciences.

Kindi developed a mathematical scale to determine in advance, based on the phases of the Moon the most critical days of an illness. He invented a discipline of medicine called posology, which dealt with the dosages of the drugs. Dosages for the drugs were a guessing game in the ancient world. He formulated easy-to-use table that pharmacists could refer to when filling out prescriptions. By documenting amounts with a mathematical formula that anyone could follow, al-Kindi revolutionized medicine. Drugs could now be formulated according to set amounts with the result that all patients would receive standardized dosages. His book on posology, *Risala fe ma'rifat quwa al-adwiya al-murakkaba* was translated into Latin as *De Medicinarum Compositarum Gradibus Investigandis Libellus* (The investigation of the strength of compound medicine).

(2) **Abu- Bakr ar-Razi** (865-925)

Muhammad ibn Zakariya Razi was a pioneer in many areas of medicine including paediatrics, infectious disease, neurosurgery, ophthalmology, and therapeutics. For instance, he wrote the first work on paediatrics, *Diseases in Children.*

Abu Bakr al-Razi (a resident of Ray, hence Razi) was the first to invent surgical suturing, to make mercury ointment and to introduce a fully detailed explanation of paediatrics, gynaecology, obstetrics, ophthalmology and eye diseases. He pioneered in conducting experimental research in medical sciences. He also tried proposed remedies on animals in order to evaluate their effects and side effects. He conducted some experiments on animals like monkeys. He used to give them a dose of medicine and record its effect. If it produced the desired result, he would start applying it on human beings.

Razi introduced alcohol in medicine, wrote first treatise on allergy and immunology, discovered allergic asthma, discovered hay fever, wrote first scientific treatise on infectious diseases, and invented hydrostatic balance to weigh drugs. His "A Dissertation on the causes of the Coryza which occurs in the spring when roses give their scent" was the first publication on hay fever.

He was first to disagree with Galen in his "*Doubts concerning Galen – al-shukook ala Jalinoos*" which ultimately led to dismissal of theory of humours and it being non-scientific. This change in thinking was not accepted until Rudolph Virchow developed his thesis on cellular pathology in the middle of 18$^{th}$ century. He disagreed with Galen over the nature of fever and urinary ailments. He wrote 56 books in medicine. In Europe he was called Arabic Galen. If he was born in 20$^{th}$ century, we are sure he would have received Nobel Prize in medicine.

He was the first to identify many diseases such as asthma, smallpox, and chickenpox and treated them successfully. He was the first physician who used alcohol as antiseptic. He invented many tools such as the mortar and pestle that are used by pharmacists. His books *Qarabadain Kabir* (The Great Book of Formulary) , and *Qarabadain Saghir* (The Little Book of Formulary) were important in pharmacology in that they introduced 829 novel drugs. He promoted the medical uses of chemical compounds. Razi was the first to write a book on home remedies, *Tibb al-Fuqara.* In its 36 chapters, he described diets and drugs that can be found in the kitchens, pharmacies, and military camps. He was known for his intelligence as well kindness and compassion to others. He was troubled by poverty and suffering so much so that he gave away his wealth and died in destitution.

He was the first one to advocate the practice of evidence-based medicine in the Middle Ages. He promoted the skills of observation and independent thinking. He advised that physicians should be mindful of their patients mental as well physical health. Razi introduced controlled experiment and clinical observation in medicine. He carried out the earliest known example of a clinical trial employing a *control group*. Razi began by selecting two sets of patients, all of whom are showing early symptoms of meningitis. He then treated one group with bloodletting, but not the second. He writes that 'by doing this, I wished to reach a conclusion (on the effectiveness of bloodletting) and indeed all those of the second group contracted meningitis'. (Jim al-Khalili, *The House of Wisdom*, London, 2011 p. 147)

Ar-Razi was the first to state that some diseases are hereditary. He was also the first to differentiate between arterial and venous bleeding. He was the first to describe cataract removal. He recommended building hospitals away from areas where organic substances could rapidly grow rotten. In addition, he was the first to make the diagnosis of measles and smallpox in his book entitled, *'al-Judri wal-Hasba*- Measles and Smallpox', in which he introduced the symptoms and the fever accompanying both diseases. He also drew a very precise clinical discrimination between them, considering fever a medical symptom that accompanies several diseases, rather than an illness. Fever immediately ceases once the illness, causing it, is treated. Furthermore, he differentiated between the pulmonary diseases causing respiratory distress and pleurisy.

His other great achievement was in understanding the nature of illness, which had previously been described by the symptoms, but Razi made the great leap of looking for what was causing the symptoms. He made a distinction between curable and incurable diseases. In the case of smallpox and measles, he blamed the blood and, as he could not have known anything about microbes, this was a logical statement. (Queen's University Kingston, Bracken medical library has a copy of his book *Measles and Smallpox*, Arabic text with English translation, 1852).

Razi wrote extensively about human physiology and understood how the brain and nervous system operated muscles, and only the Islamic distaste for dissection prevented him from refining his studies in this area. He stated in *Kitab al-Hawi Fi Al-Tibb* that nerves had motor and sensory functions. He recognized that they originated as pairs from the brain or spinal cord where they were covered by two membranes. He described 7 cranial nerves and 31 nerves.

In a church at Princeton University, New Jersey, USA there is portrait of Razi on the stained window glass as a tribute to this great doctor. I have a computer generated, three feet long picture of this portrait, showing Razi holding his book al-Hawi written in Arabic, mortar with pestel.

Al-Razi ran the psychiatric ward in the Baghdad hospital at a time, when, in the Christian world, the mentally ill were regarded as being possessed by the devil. He is acknowledged as the father of psychology and psychotherapy. He advised physicians to study medical literature constantly to gain new information. He synthesized medicine by categorizing it into different fields like eye-disease, gastro-intestinal complaints, and dietary advice to case studies. ((Jim al-Khalili, *The House of Wisdom*, London, 2011 p. 146)

It is worth quoting here two of his sayings: 1. "All that is written in the books is worth much less than the experience of a wise doctor" 2. Truth in medicine is an unattainable goal and the art as described in the books is far beneath the knowledge of an experienced and thoughtful physician:.

### (3) Al-Zahrawi 936-1013

Abul Qasim al-Zahrawi wrote a book, *Kitab al-Tasrif li-man 'Ajizja 'an al-Ta'lif* (The Arrangement for One Who is Unable to Compile [a Manual for Himself]), a compendium of 30 volumes on medicine, surgery, pharmacy and other health topics compiled during a 50-year career. Its last volume, the 300-page On Surgery, was the first book to treat surgery as a separate subject and the first illustrated surgical treatise, covering ophthalmology, obstetrics, gynaecology, military medicine, urology, orthopaedics and more. It remained a standard surgical reference in Europe until the late 16th century. (Queens University Kingston medical library has English translation with Arabic text and commentary – *On Surgery & Instruments*- by by M. S. Spink and G. L. Lewis, London 1973)

al-Zahrawi described a vast repertoire of procedures, inventions and techniques, including thyroidectomise, extraction of cataracts and an innovative method of removing kidney stones by diversion through the rectum that dramatically reduced the mortality rate for the procedure, compared to the method Galen recommended.

The *Arrangement of Medical Knowledge* was the earliest text to deal with dental surgery in detail, including re-implantation of dislodged teeth. It also described the carving of false teeth from animal bone, as well as how to correct non-aligned or deformed teeth. al-Zahrawi also detailed procedures still used by today's dental hygienists to remove calculus deposits from teeth.

al-Zahrawi used ink to mark the incisions on his patients' skin, now a standard procedure worldwide. He was the first one to wear a green gown in the surgery room, now used the world over. He was the first to use catgut for internal sutures, silk for cosmetic surgery and cotton as a surgical dressing. He described, and probably invented, the plaster cast for fractures-a practice not widely adopted in Europe until the 19th century. He produced annotated diagrams of more than 200 surgical instruments, many of which he devised himself. His meticulous illustrations, intended as both teaching tools and manufacturing guides, are the earliest known and possibly the first ever such published diagrams. His best-known inventions were the syringe, the obstetrical forceps, the surgical hook and needle, the bone saw and the lithotomy scalpel-all items in use today in much the same forms.

A list of major surgical procedures that Al-Zahrawi describes reads like a compendium of medicine in itself. Among his "firsts" were:

-Exposure and division of the temporal artery to relieve certain types of headaches
-Extraction of cataracts
-Guillotine tonsillectomy (as opposed to the more painful snare or ligature methods)
-Tracheotomy

-Using a hook to extract a polyp from the nose
-The supine posture for childbirth (now known as "Walcher's position")
-Application of ligature for bleeding vessels
-Treatment of anal fistulas
-Reduction of a dislocated shoulder (centuries before European techniques)
-Removal of thyroid cysts
-Thyroidectomy
-Mastectomy to treat breast cancer
-Surgery for breast reduction
- discussed non-aligned teeth and how to rectify these.
- developed the technique to prepare artificial teeth and to replace defective teeth by these.
- described ligaturing of blood vessels long before Ambroise Pare.
- invented a bulb syringe for giving enemas to children and a metallic bladder syringe and speculum to extract bladder stones.
- early plastic surgeons who performed many plastic surgery procedures.
- developed new technique in cauterization and applied it on 50 different operations.
- first physician to describe an ectopic pregnancy, and the first physician to identify the hereditary nature of haemophilia.
- devised a mothod for treating a dislocated shoulder (now known as Kocher's method)
- describe the migraine surgery procedure that is enjoying a revival in the 21st century, spearheaded by Elliot Shevel a South African surgeon

He invented 200 surgical instruments such as the scalpel and sutures for stitching wounds. He also established surgical methods and procedures, such as stopping a haemorrhage by coagulation as well as ligature to stop the flow of a bleeding artery. He was also the first to set the basics of the science of surgical endoscope and used syringes and surgical punctures. He managed to do a lithotripsy for a bladder stone with the use of what resembled a modern endoscope. He was also the first to invent and use the vaginal speculum.

In hematology, Abu al-Qasim al-Zahrawi wrote the first description on hemophilia, a hereditary genetic disorder, in his *Al-Tasrif*, in which he wrote of an Andalusian family whose males died of bleeding after minor injuries

Medical historians claimed that al-Zahrawy was the first to devote special attention to surgery and separate surgery from medicine. Also, al-Zahrawi's surgical research replaced all former inquiries and remained the main reference in surgery for more than 500 years. His research included labelled drawing and pictures of more than 200 surgical tools. These had an immense influence on Western surgeons later, especially those who reformed and improved surgery in Europe in the thirteenth century. Haller, the great physiologist, said, "All the European surgeons who emerged after the fourteenth century turned to that research to quench their thirst for knowledge." This book was the chief reference for surgery.

Muslims remained the pioneers in surgery up until the 15th century European students came to the Islamic countries to learn and return to their countries to apply what they had learned. This indicated how essential surgical science was and how important it was to separate it from internal medicine.

**(4) Ibn-Sina (980-1037)**

Avicenna (Ibn Sina) is considered the father of modern medicine, for the introduction of experimental medicine, clinical trials, risk factor analysis, and the idea of a syndrome in the diagnosis of specific diseases, in his medical encyclopedia, *The Canon of Medicine* (c. 1025), which was also the first book dealing with evidence-based medicine, randomized controlled trials, and efficacy tests.

Avicenna's contributions to medicine include the discovery of the contagious nature of infectious diseases, the introduction of quarantine to limit the spread of contagious diseases, the introduction of experimental medicine, evidence-based medicine, clinical trials, randomized controlled trials, efficacy tests, clinical pharmacology, and the idea of a syndrome in the diagnosis of specific diseases, the first descriptions on bacteria and viral organisms, the distinction of mediastinitis from pleurisy, the contagious nature of phthisis and tuberculosis, the distribution of diseases by water and soil, and the first careful descriptions of skin troubles, sexually transmitted diseases, perversions, and nervous ailments, as well the use of ice to treat fevers, and the separation of medicine from pharmacology, which was important to the development of the pharmaceutical sciences

He discovered many of the ailments which are still widespread, such as Ankylostoma parasite and he called it 'the round worm', preceding the Italian scientist Dobby Bingo by nearly 900 years.

In the third book of his masterpiece *Canon of Medicine*, Avicenna described patients with symptoms of carotid hypersensitivity syndrome. These patients, who had excessive yawning, fatigue, and flushing, dropped following pressure on their carotids. Based on such history, it seems that Avicenna was the first to note the carotid sinus hypersensitivity.

http://www.internationaljournalofcardiology.com/article/

Ibn-Sina was the first to describe meningitis and differentiate between of cerebral origin and that resulting from external (or peripheral) cause. He also described stroke that results from excessive blood flow, opposing what had been believed by the ancient Greek physicians. He differentiated between the renal colic and intestinal colic. Another breakthrough by Ibn-Sina is his discovery of the modes of infection of some diseases like measles and smallpox and that their contagious nature is due to tiny living organisms in water and air. He once said, "*Water contains tiny living organisms, unseen by the naked eye, causing some diseases*." This was confirmed later in the 18th century by Van Leu-hook and other scientists after the microscope was invented. Hence, Ibn-Sina was the first to establish parasitology, which is a very important branch in modern sciences' He was the first to differentiate between primary and secondary meningitis and other, similar diseases' He also described tonsillectomy, and added his own opinion about some kinds of cancers, like liver and breast cancers and lymph node tumours as well as other tumours.

Ibn-Sina excelled in surgery. He mentioned several methods to stop haemorrhages; whether by legation, pack insertion, cauterization, and chemical cauterization or pressing veins against flesh. He also dealt with arrows and how to get them out of wounds, warning surgeons against hurting a vein or a nerve while pointing out that understanding human anatomy is crucial for surgeons.

Ibn-Sina was the first to describe the eye's six intrinsic muscles. He also said that the optic nerve is the organ that is responsible for vision, not the lens, as it had been believed before. He performed many fine surgical operations such as early-stage-malignant tumour excision. Moreover, he performed tracheotomy and laryngology and excised pleural abscesses. He also treated haemorrhoids by ligature, described urinary fistulas with precision and introduced a treatment for anal fistulas that is still in use. He also dealt with kidney stones and explained how to extract them, along with the precautions that must be taken. Additionally, he explained the indications of using the catheter.

Ibn-Sina had immense experience in treating venereal diseases. He described some of the gynaecological diseases very precisely, like vaginal obstruction, fibroids and miscarriages. He also spoke about diseases that mothers would catch in their postpartum period such as haemorrhage and blood retention which may cause tumours and fevers. He also pointed out that puerperal sepsis results from difficult labour or intrauterine fatal death; a fact that had not been known before his research. He also dealt with the gender of the fetes and attributed it to the father rather than to the mother; this is a fact which was confirmed later by modern genetics.

Ibn-Sina had vast knowledge of dentistry. He said that the main purpose of treating tooth decay was to clear out the decayed part and analyze the substance which caused it. Note that the basic principle in treating the teeth is maintain them through technically preparing the cavity removing the decayed parts from the tooth then refill it with the proper filling to compensate for the lost part of tooth. Thus, the tooth would regain its function anew.

The *Canon* laid out the following rules and principles for testing the effectiveness of new drugs and medications, which still form the basis of clinical pharmacology and modern clinical trials:

*"The drug must be free from any extraneous accidental quality."

*2 "It must be used on a simple, not a composite, disease."

*3. "The drug must be tested with two contrary types of diseases, because sometimes a drug cures one disease by Its essential qualities and another by its accidental ones."

*4. "The quality of the drug must correspond to the strength of the disease. For example, there are some drugs whose heat is less than the coldness of certain diseases, so that they would have no effect on them."

5. "The time of action must be observed, so that essence and accident are not confused."

6. "The effect of the drug must be seen to occur constantly or in many cases, for if this did not happen, it was an accidental effect."

7. "The experimentation must be done with the human body, for testing a drug on a lion or a horse might not prove anything about its effect on man."

Avicenna found that drugs and diet are related in treating medicine. He understood that some stomach ulcers were from physical causes and others from mental worry and depression. Avicenna urged surgery to remove cancer and used music to help heal his patients.

Ibn-Sina believed that many diagnoses could be made by simply checking the pulse and the urine, and a large part of the Canon is given over to making diagnoses from the color, turbidity, and odor of urine. Of course, this also needed to be set alongside the Islamic holistic approach of looking at diet and background.

Avicenna, in his *Canon of Medicine*, recognized the power of cold to produce insensibility of a part (Gruner, 1930), and Yudin (1945) notes that in the middle of the seventeenth century Thomas Bartholin experimented with refrigeration anaesthesia i.e. sensory changes in nerve blocks induced by cooling. He also identified certain plants with pharmacological action such as mandragora or nightshade, opium and henbane and gives various recipes for inducing both anaesthesia and analgesia before surgery.

His other breakthroughs were some suggestions for infant care and, based upon his belief that bad water was responsible for many ailments, he included guidelines on how to check the purity of water. Many of his remedies were ultimately ineffective, but he had many more hits than misses and contributed greatly to the history of medicine.

Ibn Sena was the first physician who advocated the theory of delayed splintage, suggesting that fractures should not be splinted immediately but only after several days. He also discussed how to deal with a fracture to the first metacarpal bone in the thumb, which modern textbooks describe as the "Bennett's fracture" who supposed discovered it in 1882. (Jim al-Khalili, *The House of Wisdom*, London 2011, p 179)

Spinal disorders, particularly spine traumas and their complications, have been one of the most challenging problems throughout the history of medicine and, indeed, throughout the history of humanity. In the *Canon* he provided detailed accounts of spinal disorders and strategies for their management with original contributions.

Ibn Sena devised the "floating man" thought experiment to refute the moral belief of earlier Muslim theologians that our physical bodies are all that exists. In the psychology section of *Kitab al-Shifa* he described a scenario that he believed proves the immateriality of human soul. The thought experiment told its readers to imagine themselves created all at once while suspended in the air, isolated from all sensations, which includes no sensory contact with even their own bodies. He argued that, in this scenario, one would still have self-consciousness. Because it is conceivable that a person, suspended in air while cut off from sense experience, would still be capable of determining his own existence, the thought experiment points to the conclusions that the soul is a perfection, independent of the body, and an immaterial substance. The conceivability of this "Floating Man" indicates that the soul is perceived intellectually, which entails the soul's separateness from the body. Rene Descartes words '*I think therefore I am'* on the issue of mind/body dualism runs close to Ibn Sena's arguments. (Wikipedia.org)

As a tribute to Ibn Sena his portrait hangs in the Hall of ***Faculty of Medicine*** in the University of ***Paris***. In the Bukhara museum there are displays showing many of his writings, surgical instruments from the period and paintings of patients undergoing treatment.

**(5) Ibn al-Nafis (1213-1288)**

Ibn Nafees contradicted Galen's theory of the presence of a cavity or an opening, between the left and the right ventricles. Ibn Nafees corrected this error and as a consequence he discovered the minor circulatory system. While studying the blood movement in the human body, he noticed that the blood reaching the left ventricle is mixed with air (oxygenated) and that the blood which has been cooled and has reached the right ventricle has no passage inside the heart and has no way out except to the lungs. Thus, he concluded that the blood in the right ventricle after it has been warmed must be carried to the left through the lungs. He rejected and disproved any other passage for the lood and that it moves in one direction not subject to any tide or reflux.

Ibn Nafees proved that the blood movement is as follows: It flows from the right ventricle to the lungs where it is oxygenated. Then, it flows from the lungs to the left ventricle through the pulmonary artery. He further described the pulmonary artery, asserting that it has two impenetrable and very delicate layers. He also called it an artery for its pulsing nature. Thus, he presented a very precise description of the minor (pulmonary) circulatory system.

Ibn Sena had said that the heart has three ventricles; Ibn Nafis proved there are only two. Galen and Ibn Sena had said there is a bone under the heart; ibn Nafees proved both of them wrong. Galen had said optic nerve from the brain – right affects the right eye and left affects the left eye, ibn Nafees said each nerve goes to the opposite side. Ibn Nafees was the first physician to perform brain surgery. He was the first one to state blood flows through the capillaries. He was the first one to say brain controls sensation, movement and cognition.

His other observation was that the heart was nourished by the web of capillaries surrounding it not, as proposed by Avicenna, the right ventricle of the heart. He touched upon the subject of the role of capillaries in circulation, proposing that the pulmonary artery and vein were linked by microscopic pores; it would not be until four centuries later that this theory was rediscovered and the idea of capillaries was extended to the rest of the body.

The pulse was well known to Islamic medicine, and to the Egyptians before them, but al-Nafis was the first to understand the mechanisms behind the pulse. Galen proposed that the arteries pulsed naturally, and that the entire length of the artery contracted simultaneously, but Al Nafis believed that the pulsation was caused by the action of the heart pushing blood around the body. He correctly noted that the pulsation of the arteries lagged behind the action of the heart and that it did not occur simultaneously down the whole length.

However, al- Nafis believed that this motion of the blood was a means to disperse spirit, which would burn out the heart if it resided there for too long. He proposed that this spirit would become stagnant if left to rest in the arteries, and so the circulation was essential. Whilst his theories of the heart and pulmonary circulation were reliant upon this invisible spirit, there is little doubt that his proposals were a major step towards understanding how the body works. Sadly, much of his knowledge did not pass into western history.

Some of his other observations were based upon his observations in dissection, of which he was a great proponent, and he corrected many misconceptions in physiology concerning the brain, gall bladder, bone structure and the nervous system. Sadly, because very little of his work was translated into Latin, his work was woefully underutilized by western scientists and even the likes of Leonardo Da Vinci made incorrect observations based upon Galen and Avicenna, without realizing that Al Nafis had already addressed many of these issues.

His other great contribution to Islamic medicine was his pharmacological works, which drew remedies from all across the world but also introduced mathematics and the idea of dosages to administration of treatments.

Early Muslims progressed and reached such great heights in ophthalmology that no one has ever reached before for many centuries. Ophthalmology flourished in an unprecedented way. Neither the Romans nor the Greeks could compete with the Muslims' achievements. It is no wonder that many writers considered ophthalmology an Arab specialty.

**(6) Ibn al-Quff (1233-86)**

Ibn al-Quff was apparently the Arab physician to call for a standard set of weights and measures in medicine and pharmacy. He is also known to have excelled in anatomical descriptions of the body, especially of the heart and the blood system. He “described accurately and with much care what we now call the capillary system, which connects arteries with veins for the completion of the blood circulation. The phenomenon was fully explained 400 later in the monumental work of the Italian anatomist, Marcello Malpighi (1628-94) with the aid of microscope. It was four centuries later before Europeans fully explained these structures and functions.

Ibn al-Quff also described in great detail the stages of growth of embryos. In his book on embryology *al-Jami al-Gharaz* he says, “The formation of a foam stage is the first six to seven days, which then in 13 to 16 days, is gradually transformed into a clot, and in 28 to 30 days into a small chunk of meat. In 38 to 40 days, the head appears separate from the shoulders and limbs. The brain and heart followed by the liver are formed before other organs. The fetus takes its food from the mother in order to grow and replenish what it discards. There are three membranes covering and protecting the fetus, of which the first connects arteries and veins with those in the mother’s womb through the umbilical cord. The veins pass food for the nourishment of the fetus, while the arteries transmit air. By the end of seven months, all organs are complete…. after delivery, the baby’s umbilical cord is cut at a distance of four-finger breadth from the body, and is tied with fine, soft woolen twine. The area of the cut is covered with a filament moistened in olive oil over which a styptic to prevent bleeding is sprinkled… After delivery, his mother nurses baby whose milk is the best. The midwife puts the baby to sleep in a darkened quiet room…. Nursing the baby is performed two to three times daily. Before nursing, the mothers breast should be squeezed out two or three times to get rid of the milk near the nipple”.

Ibn al-Nafis, a student of ibn al-Quff, is noteworthy for his discovery and description of the pulmonary system, a feat repeated by William Harvey in the 17$^{th}$ century. (Toby Huff, *The Rise of Early Modern Science*, Cambridge Uni. Press 1993, page n176, 177)

In the 12th century, Zayn al-Din al-Jurjani provided the first description of Graves' disease after noting the association of goitre and exophthalmos in his *Thesaurus of the Shah of Khwarazm*, the major medical dictionary of its time. al-Jurjani also established an association between goitre and palpitation.

(7) Ibn Zuhr (1091-1161)

Spanish physician Abu Merwan Abd al-Malik Ibn Zuhr was one of the earliest physicians known to have carried out human dissection and postmortem autopsy. He proved that the skin disease scabies was caused by a parasite, a discovery which upset the theory of humors supported by Hippocrates, Galen & Ibn Sena. The removal of the parasite from the patient's body did not involve purging, bleeding, or any other traditional treatments associated with the four humors.

His most effective accomplishments was proof that scabies is caused by the itch mite, and that it can be cured by removing the parasite from the patient's body without purging, bleeding or any other (often painful) treatments associated with the four humours. This discovery sent a shudder through medical science, for it unshackled medicine from strict reliance on the theory of humours and, with that, blind acceptance of Galen and Ibn Sina. He made 5 notable discoveries in medicine: described tumours, inflammation of the middle ear, pericarditis, paralysis of pharynx, tracheotomy.

Ibn Zuhr also wrote about how diet and lifestyle can help a person avoid developing kidney stones. He gave the first accurate descriptions of neurological disorders, including meningitis, intracranial thrombophlebitis and mediastina tumours. He made some of the first contributions to what became modern neuropharmacology. He provided the first detailed report of cancer of the colon. Ibn Zuhr was the first to explain how to provide direct feeding through the gullet or rectum in cases where normal feeding was not possible—a technique now known as parenteral feeding.

Ibn Zuhr introduced the experimental method into surgery, using animals as test subjects—for example, a goat to prove the safety of a tracheotomy procedure he devised. He also performed post-mortems on sheep while doing clinical research on how to treat ulcerating diseases of the lungs. Ibn Zuhr is the first physician known to have performed human dissection and to use autopsies to enhance his understanding of surgical techniques.

Ibn Zuhr established surgery as an independent field by introducing a training course designed specifically for future surgeons before allowing them to perform operations independently. He differentiated the roles of a general practitioner and a surgeon, drawing the metaphorical "red lines" at which a physician should stop during his management of a surgical condition, thus further helping define surgery as a medical specialty. He was also among the first to use anaesthesia, performing hundreds of surgeries after placing sponges soaked in a mixture of cannabis, opium and henbane over the patient's face. His magnum opus *Al-Taisir Fil-Mudawat Wal-Tadbeer* (Book of Simplification Concerning Therapeutics and Diet) was influential in the progress of surgery.

We have detailed here seven Muslim physicians who made amazing medical breakthroughs. There is a long list of competent physicians like Ali ibn Raban Tabari,  Ali ibn Abbas, Ibn Maskaway, Ali ibn Isa, Ali ibn Rizwan, Ibn Jazla, Ismail Jurjani, Muffaq al-Din, Rashid al-Din Fadhlallah, Mahmudh Jaghmini, Abul Barkat Baghdadi, Ibn al-Jazar, Ibn al-Wafid, Ibn Bajja, Ibn Rushd, Ibn al-Khatib, Hakim Ali Gilani, Hakim Arzani, Sharf al-Din, Saleh ibn Nasrullah, who were trailblazers in their own right. We hope to detail their medical contributions in a subsequent article.

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**References**


- Albucasis – on Surgery and Instruments, Arabic text with English translation and commentary by M.S. Spink, University of California Press, 1973. A copy is in Queen's University Health Sciences Library.
- Jim al-Khalili, *The House of Wisdom*, London 2011.
- Prof Syed Zillur Rahman, Commentaries and Translations of Ibn *Sena's Canon of Medicine*, Urdu Aligarh 1986. (English translation in print).
- Badr Azimabadi, *Great Personalities of Islam*, Dehli, 1998
- Elgood C. *A medical history of Persia and the Eastern Caliphate*. Cambridge: Cambridge University Press, 1951.
- Zakaria Virk, *Muslim Contributions to Sciences* Urdu, Dehli 2011

Various internet sources and following websites.

http://islamquranscience.org article Golden Age of Islamic Medicine
http://www.nlm.nih.gov/hmd/arabic/med_islam.html National Library of Medicine USA
http://books.google.com/books?id=mjVra87nRScC&pg=PR8#v=onepage&q&f=false
http://www.alislam.org/egazette/articles/Muslim-Contribution-to-Pharmacy-201009.pdf
www.muslimhertiage.com
www.ibnsinaacademy.org Aligarh, India

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Chapter 8

# Hospitals and Health Care in Medieval Islam

Medieval Muslims adopted every institution of public service they found in the countries they conquered (Syria, Iraq, Iran, and Byzantium) during the medieval times. In Iran they found houses for the sick called *bimaristan* (hospitals), functioning as a center of public health care. Muslim rulers in Central Asia, Khorassan and India changed the Persian name to *Daru al-Shifa*.

In the Islamic world a *Hakim* or a wise man has played a central role in the dissemination and transmission of knowledge, and he has usually been a writer, a poet, an astronomer, a mathematician or a physician. Both the wise man and physician are called *Hakim*. Many of the renowned scientists of Islam were physicians such as Zakariya al-Razi, Ibn Sena (Avicenna), Ibn al-Haytham, Ibn Rushd, Nasir al-Din al-Tusi, and Qutab al-Din Sherazi . Since knowledge was not compartmentalized as it is today, a physician could be a scientist, a philosopher, an astronomer, & mathematician as well.

Islamic medicine was closer to modern concept of health care. It was Razi who theorized that fever is the body's natural defense mechanism. He was the first one to hint mind-body disease connection. Ibn Sena concluded that tuberculosis is an infectious disease. He set down empirical rules for testing the effectiveness of drugs, rules that will be applied for clinical drug trials nine hundred years later. He used word-association form of psychoanalysis, later used by Carl Jung. His theories about the mind found expression in modern psychology and science fiction. He defined the relationship between state of mind and state of physical health, later used by California professor Norman Cousins (d1990) who said: "*ten minutes of genuine belly laughter had an anesthetic effect and would give me at least two hours of pain-free sleep"*

The following passage from a 10th century manual for physicians reveals:

*"Since the science of medicine is very vast and the life of man too short to reach its end, therefore expert physicians … busy themselves constantly with the study of books and pore over them by night and day… Just as must read all the books written on the practice of medicine, so too must you know the relevant principles of natural science, of which medicine is a branch. You must also be proficient in the methods of logic so that you may … refute the fools who pass themselves as physicians… if you carry out you treatment effectively with diet… do not use drugs, for most of them are enemies … of nature*". [15]

**Damascus**

The first hospital in the Islamic World was built in Damascus in 706 by Umayyad Caliph Walid ibn Abdul al-Malik (668-715) which catered to the sick, the blind, and the lepers. All medical care was free. It employed many

[15] James A. Corrick, The early middle ages, page 86 (reprinted in Medieval Europe Edited by C. Warren Hollister)

physicians. Its staff, organization and equipment served as a model for later hospitals. The Caliph assigned stipends for the physicians.

The Nuri Hospital in Damascus was founded in 1154 by Turkish Sultan Nur al-Din Zangi (1118-74). According to Egyptian historian al-Maqrizi (d1442), it was paid with the ransom of King of Franks. (*al-Ifrang* i.e. European). This remained a major medical center for next 300 years. As the hospital was built during the Crusades, it was equipped with large enough buildings & medical equipment to treat the wounded. In due time it became not only a free hospital, but a first class medical center for teaching as well. [16]

Sultan Zangi donated a large amount of books to this institution. Books were rare and expensive at this time because they were all handwritten. Books were printed on printing press in the 15th century. Medical records of all patients were kept with a list of patients, their personal information, and drugs administered to them. Physicians made rounds in the morning, in the afternoon they had their private practice and gave lectures to medical students in the evening. It was restored in 1975 and currently houses *Museum of Medicine and Science in the Arab World.*


*The central courtyard of Nuri Hospital. Wikipedia*

Famous physician Allau al-Din ibn al-Nafis (1213-88) was a graduate of Nuri Hospital. He is credited with discovering pulmonary circulation of blood in 1254, 300 years before William Harvey in 1616. Al-Nafis knew that the heart had two halves and that blood passed through the lungs when traveling from one side of the heart to the other. Besides this he described capillary system as well as coronary system, which nourish the heart. Nuri Hospital remained operational for 700 years; some of the structure is still standing in Damascus.

**Baghdad**

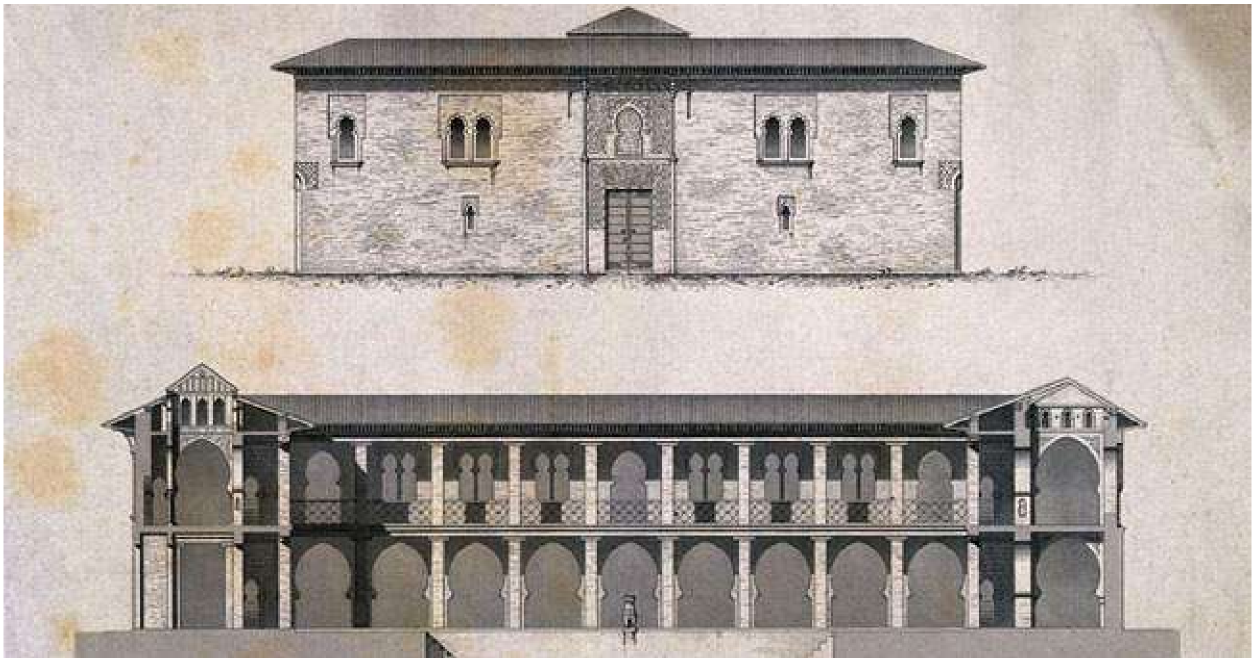
The first free public hospital was opened during the Caliphate of Harun al-Rashid. Physicians were appointed to give lectures to medical students and diplomas. In the next hundred years five hospitals were built here. All royal physicians of Abbasid Caliphs at this time belonged to Bakhtishu family Christians or Jews. Hospitals were called *Bemaristan* – Persian, house for the sick. Hospitals in Egypt were called *Mustashfi* i.e. place where someone restores health.

Caliph abu Ja'afar al-Mansur (714-775) appointed dean of the Jundi-shapur medical school of Iran as his royal physician in 766, & ordered him to have a hospital built in Baghdad. Caliph Harun al-Rashid (r786-809) ordered his royal physician Jibril ibn Bakht -ishu II (d829) to have a hospital built in the city which was completed in 790. Yuhanna ibn Masawayh (d857) was its director for some time, who made translations from Greek medical works and was teacher of celebrated physician & translator Hunayn ibn Ishaq. Al-Rashid hospital represented Jundi-shapur (Greek, Indian, & Iranian) influence which promoted hospitals as institutions dedicated to the treatment of sick.

Bookseller Ibn al-Nadim's renowned book *al-Fihrist* references a Barmakid hospital whose director was ibn al-Dahn (or Dahanai) al-Hindi who translated certain books from Sanskrit. Another Indian medic Manka al-Hindi translated the book of Shusruta into Arabic. It appears that this hospital had strong Indian influence, and it was sufficiently organized to have a director.

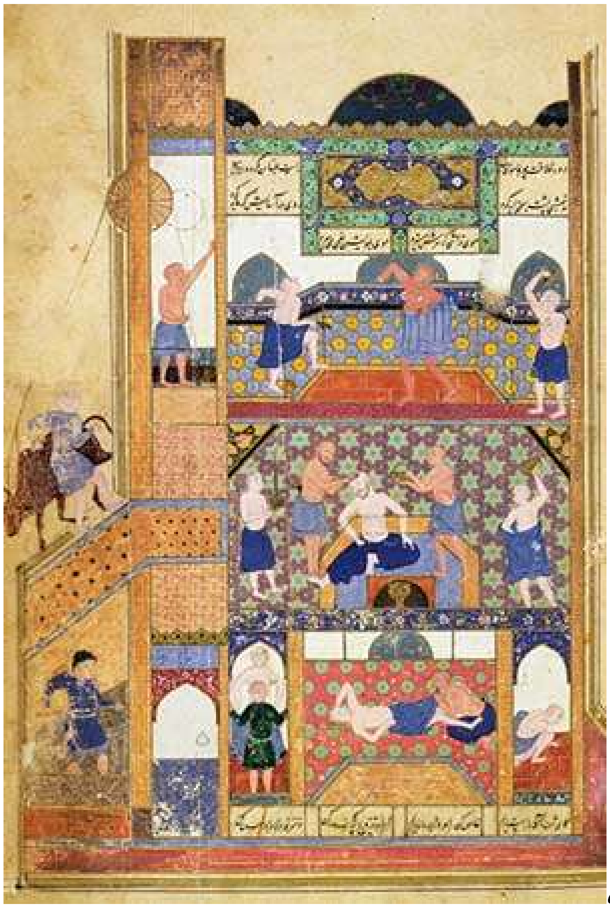
[16] Prof. Jim al-Khalili, documentary showing *Nuri Hospital* …https://www.youtube.com/watch?v=7VCQlozBJjU

Caliph abul Fadl al-Muqtadir (895-932) had two hospitals built in 918. One hospital was in the east end of the city named after his mother *al-Sayyida* and the other hospital in *Suq Yehya*, the west end of the city called *al-Birmaistan al-Muqtadari*. This hospital soon became a major medical as well as teaching center where Zakariya al-Razi (854-925) who was given the honorific title of *Arab Galen*, was director at one time, and taught his



Hospital in Grenada

*Medieval Hospital in Damascus, Syria*



*al-Adudi hospital in Baghdad, 9th century*

students. He tabulated minerals into six categories according to their chemical properties the same principle that lies behind the modern Periodic table.

In 931 Caliph al-Muqtadir learned of the death of one of his subjects due to physician's error. He instructed Sinan ibn Thabit to examine all doctors and prevent practicing until they passed a test.

Spanish traveller Ibn Jubayr (1217) visited this 200 year old hospital,

*"This great establishment is a beautiful structure stretching along the banks of Tigris. Its physicians make rounds every Monday and Thursday to examine patients and prescribe for their needs. At physician's disposal are attendants who fill drug prescriptions and prepare food. The hospital is split up into various wards, each containing a number of rooms, giving the impression that the place is as a royal place in which every convenience is provided*" [17]

By 1000 Baghdad had five hospitals. The most famous hospital of Baghdad was *Bemaristan al-Adudi* which was built by Sultan Adud al-Dawla in 981. There were 25 medical practitioners employed here including ophthalmologists, surgeons and bone-setters. Students were taught medicine from the books in the hospital library, and some physicians had written medical books themselves. Ali ibn Abbas who authored the book *Kitab al-Maliki* (liber Regius) was a member of hospital staff. All hospitals were secular, hence there were Muslim, Christian and Jewish doctors working side by side. Some of the physicians had their private practice in the city. In 1068 there were 28 physicians employed here who used to see their patients on Mondays and Thursdays. In 1184 a traveller to the city described this hospital as a magnificent castle in size. It remained operational from 981 to 1258 when it was ransacked by Helagu Khan.

2 Rehla ibn Jubayr, Travelogue - https://www.scribd.com/document/308910018/Travels-of-Ibn-Jubayr-pdf 1952

Naser-e Khushrow (d1088), a Persian traveller, described the Jerusalem hospital in these words: "*Jerusalem has a fine, heavily endowed hospital. People are given potions and draughts and the physicians who are there draw their salaries from the endowment. The hospital and the Friday mosque are on the east side of the city". [18]*

Mobile hospital was in use in Baghdad in 942. First field hospital was setup in 1122 by Mustaufi Aziz al-Din Baghdadi. When Sultan Saljuq was going on an expedition, all medical equipment and war machines were loaded on 200 camels including doctors, nurses, drugs and tents to cater the soldiers.

**Cairo**

There were 3 famous hospitals in Cairo: Ibn Tulun, Nasiri, and Mansuri.

It is said that Turkish general and Minister Fath ibn Khaqan (d861) built a hospital in Cairo, but no specific information is available. Fath was a prominent member of Samarra's literary circle, and noteworthy as a patron of many writers and poets. One of his protégé was writer al-Jahiz (868) who dedicated his work *fee Manaqib al-Turk* to him.

Cairo's oldest and first hospital was at Fustat built by Abbasid governor Ahmad ibn Tulun (835-884) in 872. Besides patients with physical ailments, mental patients were treated in a separate ward. Governor Tulun used to visit hospital daily, once a mental patient asked him for a pomegranate. Instead of eating, he threw at the governor, after that he never visited hospital. In Europe up to the $18^{th}$ century mental patients languished in prisons, some burnt at the stakes, as insanity was considered work of devil. Fustat General Hospital contained 2 bath houses, one for men and one for women. All treatment and medications were free of charge. It had a rich library. Patients were given hospital clothes and assigned beds.

It was the first hospital in the Islamic world with *waqf* revenues which guaranteed hospital's longevity. (Waqf is a charitable endowment under Islamic law, which typically involves donating a building, plot of land or other assets for Muslim religious or charitable purposes.)

The other four hospitals that were built with waqf endowment were: 1. Hospital of Badr Ghulam (d902) an army commander of Caliph al-Mutadid, Baghdad. 2. Baghkami Hospital of Baghdad built by Amir abul Hassan Baghkam (d940) commander of Caliph al-Muktafi (d908). 3. Ikhshidid Hospital of Cairo built by Kafur al-Ikhshid in 957. 4. Hospital built by Mulzzuddawal ibn Buwayh in Baghdad around 967.

In the $12^{th}$ century Sultan Salah al-Din Ayyubi (d1193) built Nasiri hospital in Cairo. By 1183 this comprised of large buildings for men, women and a separate block for the insane. Patients were reviewed twice a day and put on special diet to improve their health.

Mamluk Sultan of Egypt Mansur Qalaun (d1290) suffered from colic attack during an expedition to Syria. He was treated at the Nuri hospital. After that he vowed that one day he will build a similar hospital. Thus the splendid **Mansuri hospital** was built in 1284 with an annual endowment of one million *dirhams.* Its structural design was same as Nuri hospital, its four buildings had cruciform shape, covering 10,000 square foot. It was a citadel converted to care for the sick.

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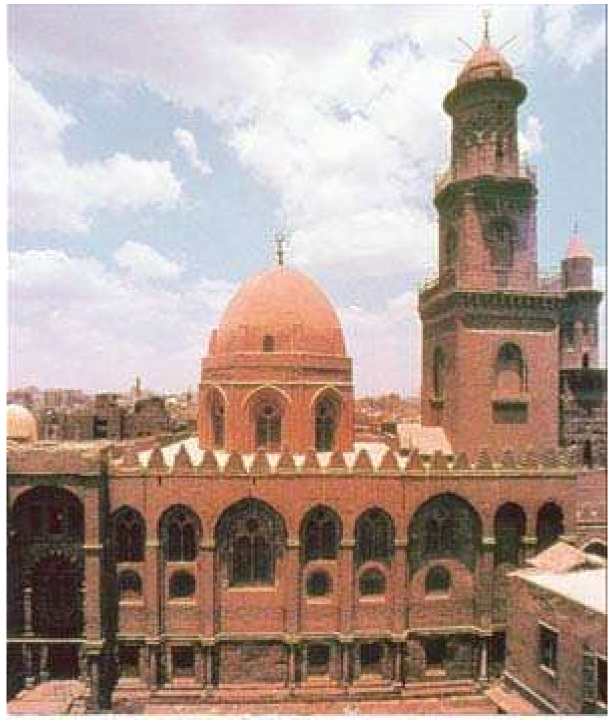
[18] *Medicine in the Crusades, page 51* books.google.ca



Bimaristan del sultan Qalaun.
El Cairo (s. XIII)

It was called *al-Maristan al-Kabir al-Mansuri*.

There were wards for patients with fevers, gastrointestinal illness, eye disorders, mental illness, the wounded, and those requiring surgery. There separate wards for men and women, female nurses for women patients. There was storage for drugs, lecture halls for the professors, kitchen and room for medical instruments. Hospital had its own pharmacy. Those people who wanted for the doctor to treat them at home had to pay, and it was normal to give birth at home i.e. no maternity wards in the hospitals.

Medical care was free; any in-patient could stay without any time restriction. On the hospital grounds there was a mosque for the Muslims and a chapel for the Christians. This hospital remained operational for 650 years. Some part of the complex can be seen in Cairo still today.

In Alexandria there was a hospital, where strangers and foreigners were treated. Those who could not visit the hospital, people were sent to their homes to ascertain their situation. Upon return they informed doctors who would prescribe medication.

**Hospitals in Palestine, Anatolia, Tunis and Morocco,**

When Sultan Salah al-Din conquered Jerusalem again in 1187 he had a hospital built in St. John's complex. There were separate wards for men, women and the insane. Patients were checked up in the morning and evening, they were given special diet so they could recover soon.

There were hospitals built in Anatolia in the 13th century, like al-Qaysariyya in 1206, Sivas hospital in 1217, and there were hospitals in Akeshir, Erzrum, and Konya.
Musicians came to these hospitals to entertain the patients. Each patient was given 5 pieces of gold when they were discharged. [19] During the Saljuq period 15 hospitals were built, 86 prominent physicians, and 50 medical works were produced. The first Ottoman hospital *Dar al-Shifa* in Bursa was opened in 1399. The hospital at Manisa was

[19] A.Y. al-Hassan, Science and Technology in Islam, page 416.

built by Hafsa Sultan, mother of Suleyman the Magnificent, in 1535. The most important hospital of Ottoman period *Dar al-Shifa Sulemaniya* was built in 1557.

In Islamic Spain first hospital was built in Granada in 1366 by Prince Muhammad ibn Yusuf ibn Nasr. There was a hospital *al-Dimna* built by Prince Ziyadat Allah in 830 in Qairawan, Tunis. In 1663 Bey Hammuda Pasha built a hospital for the insane.

In Morocco Sultan Mansur Yaqoob ibn Yusuf had a hospital built in 1190 in Marakesh. This was a fair size hospital where flowers and fruits were grown in the front yard. Water was supplied by aqueducts. In the 16th century, in Fez mental patients were housed in the house of Sidi Faraj al-Khazraji, the Spanish musician.

**Afghanistan**

In Afghanistan Sultan Mahmud (r 997–1030 AD) is credited with having built madrasas (schools of higher learning) and bimaristans in Ghazna and other cities of the Empire. The bimaristan in Ghazna seems to have comprised different wings where patients suffering from different diseases were lodged separately. [20]

India

In India the Sultans of Delhi also built *Dār al-Shifas*. Another development that took place in India was the beginning of the process of synthesizing Arabian medicine and the indigenous Ayurvedic system. This process continued during the Mughal period as well.

Dr Iqtidar Hussain Siddiqui AMU writes:

"*treatment. As the climate of India was different from the foreign lands to which the conquerors and their physicians belonged, their 'Ilm-ul-Tib (science of medicine) was not found sufficient enough to cure different ailments. They realised the need to interact with the experts of the indigenous ayurvedic system, in order to gain knowledge of their system and benefit from their experience. It was necessary because many herbs and medicines prescribed in 'Ilm-ul-Tib were not available in India. Similarly, certain medicines used in the countries of different climate did not suit the patients in India. Thus the interaction between the Muslim physicians and the Hindu practitioners resulted in synthesising the two systems*". [21]

Men of learning and talent in medicine wrote medical books on the instance of the Sultans. For instance Ilyas bin Shahab wrote two books *Rahat al-Insan* (1385) and *Tibbe Firoz Shahi*. In the sultanate of Gujrat, Shahab bin Nagori, associated with Muzaffar Shah I, wrote two books, the *Tib-i-Shahabi* (in verse) and *Shifa al-Khani* (in prose), both are extant. Many leading physicians of Delhi, both Hindu and Muslim, imparted medical training and knowledge to their students. Physicians were held in high esteem by the Sultans and Mughal Kings. There were 70 Daru –Shifa in Delhi. During the reign of Sultan Firuz Shah Tughlaq (r1351-88) there was a hospital in Firuzabad in which animals and birds were treated.

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.955.2025&rep=rep1&type=pdf

[20] Indian Historical Review 39(1) 11–18 © 2012 ICHR SAGE Publications Los Angeles, London, New Delhi

[21] Indian Historical Review 39(1) 11–18 © 2012 ICHR SAGE Publications Los Angeles, London, New Delhi, 39 I (2012)

 treating a patient at a Medieval Islamic hospital

**Features of Hospitals**

How did hospitals look like from the outside, how were they run? Muslim travellers like Ibn Batuta and al-Maqrizi have provided this information in their travelogues. In the 12th century hospitals in Damascus and Cairo consisted of many rooms, including lecture hall, kitchen, storage, pharmacy, houses, mosques and some had libraries. There was no time limit a patient could spend as an inpatient. There were fountains in the hospital complex so that fresh water was always available. Men and women were admitted to separate but equally equipped wards. People with eye ailments had separate wings, so did people with other diseases. Free medications were dispensed from out-patient clinics. There was a roster for physicians who reported to work accordingly. Doctors made rounds. There were stewards and orderlies to help the physicians. The Waqf documents stated nobody was ever to be turned away. Recreational materials and musicians were often employed to comfort and cheer patients up

Prof. al-Khalili says: "*among the features in medieval Muslim hospitals that distinguishes them from their contemporaries elsewhere were their higher standards of medical ethics. Physicians there treated patients of all religions and ethnicities… **they even adopted and adapted to Islamic thought the famous Hippocratic oath***. "[22]

Oath of Hippocrates

"*I swear by Apollo, the Physician, by Aesculapius, by Panacea, and by all the Gods and Goddesses, calling them to witness that according to my ability and judgment I will in every particular keep this, my oath and covenant: to regard him who teaches this art equally with my parents, to share my substance, and, if he be in need, to relive his necessities; to regard his offspring equally with my brethren; and to teach them this art if they shall wish to learn it, without fee or stipulation; to impart knowledge by precept, by lecture, and by every other mode of instruction to my sons, to the sons of my teacher, and to pupils who are bound by stipulation and oath, according to the law of medicine, but to no other.*

*I will use that regimen which, according to my ability and judgment, shall be for the welfare of the sick, and 1 will refrain from that which shall be baneful and injurious. lf any shall ask of me a drug lo produce death, l will not give it, nor will I suggest such counsel. In like manner I will not give to a woman a destructive pessary.*

*With purity and holiness will I watch closely my life and my art. I will not cut a person who is suffering from a stone, but will give way to those who are practitioners in this work. Into whatever home I shall enter, l will go to aid the sick, abstaining from every voluntary act of injustice and corruption, and from lasciviousness with women or men ... free or slaves. Whatever in the life of men I shall see or hear, in my practice or without my practice, which should not be made public; this will I hold in silence, believing that such things should not be spoken. While I keep this, my oath, inviolate and unbroken, may it be granted to me to enjoy life and my art, forever honored by au men; but should l by transgression violate, be mine the reverse*." [23]

[22] Dr Al-Khalili, The House of Wisdom, page 145

[23] http://jima.imana.org/article/viewFile/13050/20-1-13050 Teaching Institution

The hospital was important place of learning as clinical medicine was taught in hospitals. There were lecture halls and well stocked libraries. Medical theory was taught in the mosque and madrasah, the practical side was taught in the hospitals. The Abbasid Caliphs decreed that medical students must write a thesis, just as the modern thesis, and upon its acceptance a diploma (*ijaza*) was granted by their professor (Shaykh).

**Pharmacies (Saydalas)**

Al-Saydalas were first established in Baghdad in 754, where drugs were compounded and sold. *Al-Attar* sold simple drugs (*Mufrid*). The drug stores and the work carried on in them, was inspected by *Muhtasib* (inspector/controller). Market Inspectors were responsible for checking without warning the cleanliness of the containers, preparation of syrups, their dispensing & drugs (*safufat – powders, pills – aqras, robs – rabubat, electuaries – ma'ajin*). During the reign of Caliph Mamun al-Rashid (d.833) licensing system was introduced.

Physicians were not allowed to own or operate a pharmacy. In large cities, drug stores were owned by well off persons. While European apothecaries used dung and other substances, Islamic pharmacies used herbs and spices and such substances that showed positive effect on the patient. Al-Kindi, Al Razi, Ibn Sena, & al-Biruni, discovered many new drugs for their pharmacies. Al-Kindi applied mathematics to pharmacology by quantifying the strength of drugs. He developed a mathematical scale to quantify the strength of drug and a system, based the phases of the moon that would allow a doctor to determine in advance the most critical days of a patient's illness.

Caliph al-Mamun and al-Mu'tasim instructed that all pharmacists must have a license for their business. Pharmacists were provided class room training, and gained experience about various drugs by working as interns to get hands on experience.

The first medical formulary (*Aqrabadin*) was written in Arabic by Sabur bin Sahl (d.869). The book included recipes for compounding the drugs, remedies for ailments, their pharmacological actions, dosage and the methods of administrations. It was written as a guidebook for pharmacists. It was used for training until it was superseded *Aqrabdin* of ibn Tilmidh, dean of Adudi hospital.

In Baghdad the druggists and physicians had to pass an examination in order to obtain a license to practice. Licensed pharmacists were called *Sayadala*. Sinan ibn Sabit (d.943), director of Baghdad hospital, was the first administrator of licensing department and founder of public health system. [24]
Al-Kindi (d873) invented a branch of medicine called posology, which dealt with the dosages of drugs. In the ancient world dosages for the drugs were a guessing game. He created easy-to-use table that pharmacists could refer to when filling out prescriptions. By documenting amounts with a mathematical formula that anyone could follow, al-Kindi revolutionized medicine. Drugs could now be formulated according to set amounts with the result that all patients would receive standardized dosages. His book on posology, *Risala fe ma'rifat quwa al-adwiya al-murakkaba* was translated into Latin.[25] This system is still used the world over.

**Administration of hospitals**

A hospital was run by three officials:

1. Administrator was in-charge of the staff and day today running. His appointment was political; therefore he did not have to be a doctor. 2. Director of the hospital was a doctor who was called '*mutawalli*'. 3. Chief pharmacist (*al-shaikh al-saydalani*) supervised the hospital pharmacy.

In Baghdad it was imperative for doctors to pass an exam before they could practice. In 931 Caliph al-Muqtadir ordered Sinan ibn Thabit (880-943), a physician himself, to conduct exams. He issued licenses to 860 doctors. Sinãn brilliantly directed the hospitals and medical administration of Baghdad and also started mobile hospitals in rural areas.

[24] https://www.academia.edu/6171059/Muslim_contributions_to_Pharmacy

[25] https://www.alislam.org/library/articles/Muslim-Contribution-to-Pharmacy-201009.pdf

He was a Sabian, not a Muslim, and he cared for the faithful and unfaithful without discrimination.

In the 13th century Sultan Mansur Qalaun set up *waqf* for the Mansuri hospital which consisted of mosque, chapel, separate wards for patients, library and pharmacy. The hospital was housed in a vacant palace, it could house 8000 people, and 4000 patients were treated daily. Some hospital properties included caravanserai, shops, mills and villages. There were laws enacted in the 10th century that all hospitals be open 24 hours. Some hospitals were teaching institutions where doctors, nurses were given medical training.

**Model for European hospitals**

Islamic culture was far more advanced than Europe in the early middle ages. Medicine in Europe was to a great extent an amalgam of religion, superstition and faith.

P.K. Hitti observes that *"while (the caliphs) ... were ... (reading) Greek and Persian philosophy, Charlemagne and his lords ... were ... dabbling in the art of writing their names*". [26]
Christian and Jewish students studied in the universities of Islamic Spain where Arabic translations of Greek works, such as Aristotle, were available.

These hospitals in the Islamic world were used as prototype in Europe. Ibn Jubayr commented on the presence of Christian churches when he visited Sicily in 1185, but the only Christians institutions that he described that were set up on the model of Islamic hospitals were to be found in the Latin East, in Acre and in Tyre.[27] Hospitals were funded by donations from the founder, and other patrons.

During the crusades, Europeans began to establish hospitals inspired by the Arabs. The first hospital in Paris *Les Quinze-vingt* was founded by King of France, Louis IX after his return from the crusades 1254-1260.


Quinze-Vingts Hospital inspired by Islamic hospitals

"*At the very time European Christians were travelling across the Mediterranean*", writes Daniel Boorstin, " *to crusade against the Muslim infidels… Christian physicians in Europe were daily curing bodily ills by the wisdom of modern Muslim and Jewish doctors.*" [28]

When Islamic medical knowledge filtered into European medicine during the 12th century, so did their treatments for specific diseases. New herbs from the Islamic world were added to Western apothecaries while certain Western medicines, such as *theriac*, moved into Arab countries due to the growing Arab-European trade.

[26] Quoted in J.A. Corrick,The Early Middle Ages, page 84
[27] *Rihla ibn Jubayr*- Travelogue of Ibn Jubayr, 1952, p 346
[28] Daniel J. Boorstin, The Discoverers, Random House, NY 1983, page 347

Prof Gibb, states: "*Not only were there Arab scientists who showed great ingenuity in the practical application of scientific theory and the improvement of instruments, but their works were eagerly sought after in the eleventh and twelfth centuries. … It was out of this confrontation that there arose a new methodology, which* ***utilized the observations of Arabic physicians which independently laid down the foundations of modern science*****".** [29]

Razi's *Kitab al-Havi* (the Comprehensive book) was so popular in Europe that it was one of the nine works which made up the library of Faculty of Medicine in Paris in 1395.

Andreas Vesalius (1514-64) author of one of the most significant books on human anatomy *De Febrica*, which set the European medicine on a new path, wrote his doctoral thesis *Paraphrasis in nonum librum Rhazae medici Arabis clarissimi ad regem Almansorem* commenting on and reformulating the medical ideas of al-Razi. [30]

As a tribute to two giants of Islamic medicine portraits of Razi and ibn Sena hang in the hall of Paris Faculty of Medicine. The stained glass of a window in Princeton Institute for Advanced Study, Princeton, NJ, USA church is decorated with a portrait of Zakariya Razi. In Vienna in 1522 and in Frankfurt the entire curriculum consisted of medical works of Razi and Ibn Sena.

**Bibliography**


1. Edward G. Browne, Islamic Medicine, first edition 1921. New Delhi, 2003
2. Ehsan Masood, Science & Islam, A history, London 2009
3. Zakaria Virk, 111 Muslim Sciencedan (*Urdu)* Varanasi, India 2014.
4. J. Lyons, The House of Wisdom, Bloomberry, New York, 2010
5. Pierce Mitchell, Medicine in the Crusades, Cambridge Uni. Press, 2004 Google.books.ca
6. Jim al-Khalili, The House of Wisdom, Penguin, NY, 2011
7. Prof A.Y. al-Hassan, Science and Technology in Islam, UNESCO, Beirut 2001
8. Seyyed Hossein Nasr, Science and Civilization is Islam, UK, 1987[31]
9. https://www.academia.edu/6171059/Muslim_contributions_to_Pharmacy
10. https://www.academia.edu/10913184/Muslim_Contributions_to_Ophthalmology
11. https://www.academia.edu/6427909/Golden_Age_of_Islamic_Medicine
12. Hugh Kennedy, when Baghdad ruled the Muslim World, USA, 2004
13. James A. Corrick, The Early Middle Ages, Michigan, USA 2006
14. Michael H. Morgan, Lost History, National Geographic, Washington, 2007
15. Daniel J. Boorstin, The Discoverers, Random House, NY 1983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Chapter 9

# Scientists and scholars of Islamic Rennaissance

> *"The Muslim renaissance, which was by far the most important, its success was essentially due to the wave of enthusiasm and energy which lifted these people up for a time almost above themselves. Any renaissance is essentially due to internal causes. .. the inestimable treasure of Greek knowledge remained almost exclusively in the keeping of Muslims. Many centuries were to elapse before Islam would return them to Christendom". (George Sarton, page 549)*

[29] H.A. R. Gibb, https://www.escholar.manchester.ac.uk/api/datastream?publication pp. 90 & 91

[30] Michael H. Morgan, Lost history, National Geographic, Washington, 2007, page 190

[31] Author of this article has autographed copy of the book when he met Dr. Nasr in Kingston U, Ontario in 2007

1. Introduction, 2.Translations, 3. Chemistry 4. Natural History, 5. Medicine 6. Mathematics 7. Astronomy

Renaissance means revival in the world of art and learning. Usually renaissance refers to the period from $14^{th}$ to $17^{th}$ centuries when Europe progressed in many fields. The renaissance was not only revival of Greek and Roman learning, but a change in the outlook, an eagerness for discovery, and to explore new vistas of thought. This happened not only in the medical but in physical sciences as well.

Similar to the European renaissance, the Islamic renaissance took place in Baghdad and other cities from $8^{th}$ to $14^{th}$ centuries until the sacking of Baghdad by Helagu Khan in 1258. This was not the end of revival & of original contributions to sciences, the center of intellectual activity moved to Central Asia (Samarqand) where more work was done. One must keep in mind that during the Ottoman caliphate, Muslims continued their contributions to various fields of sciences until the $18^{th}$ century.

The translation work started during the reign of Caliph Abd Allah al-Mansur (r.754-775) when many old manuscripts from Syriac, Persian, Greek and Sanskrit languages were translated into Arabic. His son Caliph Harun al-Rashid (r.786-809) was a patron of science, art and literature. Many more Greek works were translated during his reign. He was a scholar in his own right. Caliph al-Mamun founded a scientific academy *Baitul Hikma* in Baghdad. He tried to collect as many Greek manuscripts as possible. All these manuscripts were translated into Arabic. He had gathered all kinds of scholars and a lot of intellectual work was done during his Caliphate. The assimilation of Greek knowledge was further patronized by three sons of Musa ibn Shakir of Baghdad (Ahmad, Muhammad, & Hassan). All 3 brothers spent their money lavishly in obtaining Greek manuscripts and had them translated. They were scientists in their own right and penned many treatises.

**1. Translations**

Yahya ibn Batriq ($9^{th}$ century) translated from Plato's Timaeos, Hippocrate's book on signs of death, various works of Aristotle, and Galen's *de theriac ad Pisonem*. According to Huanin ibn Ishaq his knowledge of Latin was better than Greek.

Caliph al-Mamun al-Rashid (833) was even a greater patron of translators and scientists than his father Harun. He sent a mission to the Byzantine Emperor Leon the Armenian (820) to send him Greek manuscripts. All these manuscripts were translated into Arabic. He set up an academy *Baytul al-Hikma* which included a vast library, an observatory, and residences for the scholars and research facilities. Scholars, philosophers, jurists, mathematicians, physicians, and alchemists flocked to his court to be part of the Islamic renaissance.

Al-Kindi (873) was called philosopher of the Arabs. His knowledge of Greek sciences was extensive. His more than 250 works deal with mathematics, physics, astrology, music, medicine, pharmacy, optics, and geography. He translated many Greek works into Arabic or revised many translations. His book on optics *De aspectibus* influenced Roger Bacon, & Witelo. His work *De medicinarum compositarum gradibus* was to establish posology on a mathematical basis. Many of his Arabic books were translated into Latin by Gerard of Cremona. Cardano considered him one of the twelve greatest minds.

Hunain ibn Ishaq (873) was the greatest translator of medieval times. He collected Greek manuscripts, collated them, examined the existing Syriac versions and then translated many of them. He supervised scholars doing translations and in some cases revised them. Most of the Hippocratic and Galenic writings were translated under his supervision. He left behind a catalogue of Syriac and Arabic versions of Galen's works available in his day. His critical notes in the catalogue prove his high standard of scholarship. His fellow translators were Ishaq ibn Hunain, Hubaish al-Hasan, Isa ibn Yahya, Musa ibn Khalid, Thabit ibn Qurra and Yusuf al-Khuri.

Isa ibn Yahya was a disciple of Hunain. He translated 24 Galen's books into Arabic. Musa ibn Khalid translated 16 books of Galen. Matta ibn Yunus (940) was teacher of al-Farabi. He translated works from Greek into Syriac and Arabic.

Caliph Al-Hakam III (976 Cordova) was a patron of art, science and education. He sent agents to every country of the Islamic World to pay whatever amount and acquire manuscripts or copies of them. His library in Cordova is reputed to have 400,000 volumes and its catalogue contained of 44 volumes, many of which were annotate by the Caliph himself. Abu Husain Ibrahim (991) made an improved translation of Dioscorides.

**2. Chemistry**

Khalid ibn Yazid (died 704) was an Umayyad prince, when he lost his chance to be a Caliph, decided to study alchemy in Egypt. An avid book collector, he facilitated translations into Arabic of the existing literature.

Jafar al-Sadiq (765) was a Syrian chemist, astronomer, philosopher, and physician. He knew that earth revolves around the sun. He was one of the rarest gems of Umayyad dynasty.

Jabir ibn Hayyan (f.776) was the most famous alchemist of the Middle Ages. He composed many books on alchemy like *Little Book of Balance, Book of the Kingdom, Book of Mercy*, *Book of Concentration*; some of these have been translated by Berthelot. His views are sound on methods of chemical research, a theory on geological formation of metals, sulphur-mercury theory of metals, preparations of various substances. He also dealt with various applications such as refinements of metals, preparation of steel, dyeing of cloth and leather, varnishes to water-proof cloth and protect iron, use of manganese dioxide in glass making, use of iron pyrites for writing in gold, distillation of vinegar to concentrate acetic acid. Sarton has described him "*a very great personality, one of the greatest in medieval science*." National Library of Medicine, USA has 9 of his books including *Kitab al-Usul, Kitab al-Tadabir.* https://www.nlm.nih.gov/hmd/arabic/concordancea30a59.html

Zakariya al-Razi was an outstanding figure in the history of early Islamic medicine, as well as an important writer of alchemical booklets. He gave the titles of twelve alchemical treatises that he composed. His major treatise on this topic was titled ***The Book of Secrets*** (***Kitab Sirr al-Asrar***).

Muhammad ibn al-Kathi (Baghdad 1034) wrote a treatise on alchemy Ain al-San'a wa awn al-Sana'a – Essence of the art and aid to the worker. Izz al-Din al-Jildaki (1342 Khorasan) was one of the best alchemists of medieval ages. National Library of Medicine has 3 of his books including Dīwān al-shudhūr (Nuggets of Gold).

**3. Natural History**

Abd al-Malik al-Asmai was born in (739-831) flourished in Baghdad and Basra. He wrote famous books i.e. on horses *Kitab al-Khail*, on the camel Kitab al-Ibil, on wild animals (*kitab al-wuhush*), on the sheep *kitab al-sha*, on the making of man *kitab khalq al-Insan*. The last book shows that Muslims had good knowledge of anatomy. Theologian al-Nazzam developed a curious theory of evolution. Physician al-Tabari wrote an encyclopedic work Paradise of Wisdom (*Firdaus al-Hikma*) which contained abundant information of natural history. Yaqub ibn akhi Hazm composed a treatise on horsemanship which contains rudimentary knowledge of veterinary art, the earliest work in Arabic.

Amr ibn Bahr Al-Jahiz (868 Basra) was founder of a sect named after him. His Book of Animals (*Kitab al-Haywan*) exerted great influence on Arabic literature. This book contains the germs of many theories like evolution, adaptation, animal psychology. It describes 350 types of animals.

**4. Geography**

Al-Mamun ordered geodetic measurements to determine the size of the earth. He also ordered al-Khawrizmi to draw map of the world. Al-Khawrizmi wrote a treatise on geography *Kitab Surat al-Ardh* (*Face of the Earth*), it included maps. Suleman the Merchant traveled the coastal lands of India and China, his travelogue was published in 851. Suleman the Merchant (9th century) wrote an account of his travels in the Far East in 851, it was first account of China and coastlands of Indian Ocean. He recorded finger print as signature by the Chinese. Ibn Wahab traveled to China in 870, his account was written by Abu Zaid.

Ibn Khurdabhih (912) was a notable geographer whose main work *Kitab al-Masalik wal-mamalik* (Book of roads and provinces) contained abridged narrative of his journeys in distant countries. Ahmad al-Yaqubi composed *Kitab al-Buldan* (Book of countries) conscientiously detailing topographical and a universal history up to 872. Abu Zaid al-Balkhi (934) was noted geographer and mathematician from Balkh. His *Suwar al-aqalim* (figures of the climates) contained many maps.

Ibn Serapion was a famous geographer of 10th century. In his book on geography he gave descriptions of Euphrates and Tigris, Nile Rivers and canals of Baghdad. Ibn Rusta was a Persian geographer who compiled in 903 *al-A'laq al-Nafisa* which describes various countries. Ibn al-Faqih Hamadani completed in 903 *Kitab al-Buldan* (Book of Countries). Abu Zaid compiled in 920 *Akhbar al-Sin wal-Hind* (Information about china and india). Ahmad Ibn Fadlan was sent by Caliph Muqtadir to King of Bulgarians, which gave us the earliest account of Russia. It was translated into English by Richard N Frye, is available in Queen's U. Stauffer library. Kingston, Canada (Ibn Fadlan Journey to Russia, Baghdad to Volga, Princeton, 2005, DK511.T17 I2313 2005).

Al-Hamdani (945) wrote *sifat jazirat al-Arab* which is geography of Arabia. His work on history and antiquities of Yemen the Crown (*al-Iklil*) contains information about cosmology, astronomy and philosophy of early Arabs. He composed Zij for Yemen. Abu Dulaf went to India in 942, Kashmir, Afghanistan and Sijistan the compiled a narrative of his journeys' *Ajai'b al-Buldan*. Al-Masudi (957) famous geographer and historian who traveled extensively. His book is called *Muruj al-Zahab w ma'adin al-jawahir*.

Ibn Hawqal (977) wrote *Kitab al-masalik wal-mamalik* (Book of roads and provinces) which map of each country. Ibn Hazm (1064) was one of the original thinkers of Islamic Spain. His *Kitab al-Milal wal-nihal* (religions and sects) compares 4 major religions. *Kitab tauq al-Hamama* was an erotic work. Al-Idrissi (1166 Sicily) was a famous geographer and cartographer. *Kitab nuzhat al-mushtaq* is his famous book. *Al-*Mazini traveled to Volga region and in Hungary where he witnessed trade in ivory. Mazini hailed from Granada. Ibn Jubair of Valencia, wrote his Rihla (travelogue) in the East from 1183-85, one of the best account in Arabic.

**5. Medicine**

Jirjis ibn Jibril (George son of Gabriel, d.771) ibn Bakhtyashu, a Nestorian Persian physician, was director of hospital in Gondeshapur (SW Iran) in 770. Gondeshahpur was the intellectual center of the Sassanid Empire and the home of the *Academy.* Bakhtayshu family was attached to a number of Abbasid Caliphs and exerted a deep influence on Islamic medicine in the 8th & 9th centuries. Jirjis arrived in Baghdad with two pupils which marked the beginning of scientific activity. Jirjis was the first to translate medical works into Arabic. Jibril (Gabriel) collected Greek manuscripts and wrote medical works. Christian physician Ibn Masawaih dissected apes and composed anatomical and medical treatises, in fact the earliest ophthalmological treatise extant in Arabic.

Al-Kindi wrote medical books also, the most important one is the one in which he tried to establish posology on mathematical basis. Jibril ibn Bakhtyashu (829) was grandson of Jirjis who obtained Greek manuscripts and patronized the translators. He was physician to Jafar Barmakide, then to Harun al-Rashid in 805 and later to al-Mamun.

al-Batriq (806) translated into Arabic works of Hippocrates and Galen for Caliph al-Mansur. Ibn al-Muqaffa flourished in Basra. He translated works on logic and medicine from Pahlavi into Arabic, but he is known for his translation of Books of Kings (Khuday-nama), in Arabic *Sayar al-Muluk al-ajam*. Yahya al-Batriq translated various works of Plato and Aristotle in Arabic.

Ibn Sahda al-Karkh (Baghdad) translated many medical works of Hippocrated and Galen from Greek into Syriac and Arabic.

Abu Zakariya Yuhanna Ibn Masawaih (857) wrote in Syriac and Arabic. He translated various medical works into Syriac. Apes were supplied to him for dissection by Caliph al_mu'tasim in 836. His famous book is *Daghal al-Ain* (disorders of the eye), the earliest Arabic treatise on ophthalmology. Ali ibn Sahl ibn Rabban al-Tabari (861) was teacher of Zakariya al-Razi. His magnum opus *Firdaus al-Hikma* (Paradise of wisdom) dealt with medicine, zoology, embryology, psychology, astronomy and philosophy.

Zakariya al-Razi (923) was the greatest clinician of the Middle Ages, as well as a chemist and physicist. His influence can be traced both in the East and the West for centuries. As late as 1537 renaissance physician Andreas Vesalius (d.1564) "prepared *a paraphrase of the work of 10th century Arab physician Rhazes, probably in fulfillment of the requirements of the bachelor of medicine degree"* . (R. Curley, Scientists and inventors of the renaissance, ny, 2013, page 107). Razi's monumental work *Kitab al-Hawi* and a treatise on measles and smallpox (*Kitab al-Judri wal-Hasba*) are considered masterpiece if medical literature. He composed the first book on diseases of the children; hence he was founder of pediatrics. As a consummate chemist one of his chemical treatises contains a list 25 pieces of laboratory apparatus. Sinan ibn Thabit (943) was a brilliant administrator of all Baghdad hospitals. In 931 doctors were forbidden to practice unless they had been examined and given a certificate. Sinan was director of this office; he examined more than 800 doctors.

Ali ibn Abbas al-Majusi (994) wrote for ruler Adud al-Dawla *Kitab al-Maliki*, or *Kamil al-san'at al-tibiyya.* It was more practical than al-Qanun. Muwaffaq ibn Ali al-Harawi (Afghanistan) was the first one to write on material medica in Persian. In 977 he wrote Kitab al-abniya an haqai'q al-adwiya after his extensive travels in India and Persia. It deals with 585 remedies. He distinguished between sodium carbonate and potassium carbonate (qali), knew about arsenious oxide, cupric oxide, silicic acid, antimony. Al-Tamimi (980 Cairo) made pharmaceutical experiments and wrote many on *materia medica*. His book Murshid contains information on plants and minerals etc. al-Baladi (991 Cairo) was author of *kitab al-tadbir alhabala wal-atfal* (hygiene of pregnant women and children). Arib ibn Sa'ad (Cordova 976) was author of chronicle of Islamic Spain, a book on gynecology, on the hygiene of women and obstetrics (*khlaq al-janin*).

Abul Qasim al-Zahrawi (1013 Cordova) was the greatest surgeon of medieval world. His medical encyclopedia *Kitab al-Tasrif* consisted of 30 sections, the most important being 3 volume on surgery, part of which is on obstetrics, treatment of eyes, ears and teeth. It was illustrated with surgical instruments, translated into English by Lewis and Spink and published from London in 1973. Sulaiman ibn Hasssan ibn Juljul royal physician to Spanish Caliph Hisham II, wrote *Tarikh al-attiba wal-filasifa* (history of physicians and philosophers of his time). His commentary on Dioscorides was quoted by Ibn abi Usaybia.

Ibn al-Jazzar (1009 Tunis) wrote *Zad al-Musafir* which gained much popularity. It was translated into Greek by Constantine Africanus. Ibn Maskawaih (1030 Baghdad) was a Persian physician, historian and philosopher. His popular books are *Kitab Tahzib al-Akhlaq, Kitab adab al-Arab wal-Furs,* Tajarib al-Umam. Ibn

Sena (1037 Iran) was called Prince of Physicians due to his expertise in medical matters and his encyclopedic knowledge. Sarton has called him "*the most famous scientist of Islam and one of the most all races, places and times". (Page 709).* His notable works *are Kitab al-Qanoon and Kitab al-Shifa, kitab al-Isharat. Al-Qanun* remained supreme for six centuries. In Europe he was the undisputed authority besides Galen, his al-Qanun was used in the European medical schools until the 16th century.

Ibn al-Wafid (1074 Toledo) wrote *kitab al-adwiya al-mufrada* (Simple drugs) based on Galen and Dioscorides. He used diet for treatment and if drugs were needed he used simple ones. He devised a method of investigating the action of drugs.

Ibn Ridwan (1067 Cairo) wrote many books on medicine, most popular was his commentary on Galen's *Ars Parva*. His treatise on hygiene was called F*ee Daf Mudar al-Abdan bi-ard Misr.* Ali ibn Isa (11th century) was the most famous oculist. His book on ophthalmology Tadhkira al-Kahhalain (epistle to eye doctors) is the oldest Arabic work on eye diseases. It is very detailed and comprehensive.

Ibn Rushd (1198) was a Muslim judge, physician, astronomer and commentator. He was the greatest philosopher of the medieval times. He said no one is taken twice with the smallpox. He understood and explained the function of retina. Hibbatallah ibn Malka(1175 Baghdad) Jewish physician and astronomer who embraced Islam late in life. He wrote a commentary on Galen's anatomy. He was blind and deaf. He dictated *al-Mu'tabar fil Hikma* to various disciples.

Abd al-Latif Baghdadi (1231) was most voluminous writers of his time. During his stay in Egypt he examined a large number of skeletons. This was one of the earliest examples of a postmortem autopsy. He also authored an important tract on diabetes. Lisan al-Din Ibn al-Khatib (1375 Grenada) composed a number of medical treatises as well as treatises in almost all other branches of learning, with the number of titles exceeding 60. Musa ibn Maimoon knowledge was derived from al-Razi, Ibn Sina, Ibn Waif, and Ibn Zuhr.

**6. Mathematics**

The greatest mathematician of the time was al-Khwarizmi. His knowledge of algebra exerted lasting influence on medieval mathematics. Hindu numerals were transmitted to the West through his works. Al-Kindi the notable philosopher of this time wrote four books on the use of Hindu numerals. The earliest translator of Ptolemy's al-Majest into Arabic was the Jew Sahl al-Tabari. Hajjaj ibn Yusuf ibn Matar made another translation in 829. Al-Abbas ibn Said al-Jauhari wrote commentaries on *Almajest & Elements*. Hajjaj was the first translator of Euclid's *Elements* into Arabic as well as first translator of Almajest. Sahl ibn Bashr Jewish astrologer from Khurasan wrote a book on algebra.

Two of the Musa brothers (Muhammad & Hasan) were interested in geometry. Third son Ahmad was a student of mechanics (*ilm-al-Hayal*) and wrote a notable book on this topic. They devoted their wealth to acquisition and translation of Greek manuscripts. They employed many translators (Hunain ibn Ishaq and Thabit ibn Qurra) to do the translation work.

Abu Said al-Darir (845) was an astronomer and mathematician. He wrote a treatise on geometrical problems and another on the drawing of meridian. Al-Khawrizmi syncretized Greek and Hindu knowledge. His most important work in the history of mathematics is *Kitab al-Jabr wal-Muqabila* which made him one of the founders of algebra as distinct from geometry. His trigonometric and astronomical tables were revised by Spanish Maslama al-Majriti.

Al-Mahani (874 Kirman) a Persian mathematician wrote commentaries on Euclid and Archimedes. He is famous for al-Mahani's equation. He made observations of lunar and solar eclipses and planetary conjunctions, which were used Ibn Yunus. Hilal al-Himsi (883) translated first four books of Apollonios. Ahmad ibn Yusuf Egyptian mathematician wrote a book on similar arcs, a commentary Ptolemy's Centiloquium and a book on proportions. Later book influenced Leonardo de Pisa.

Al-Fadhl ibn Hatim Al-Nairizi (922 Shiraz) wrote commentaries on Ptolemy and Euclid. He authored an elaborate treatise on spherical astrolabe. Thabit ibn Qurra (901) led a school of translators which translated into Arabic mathematical classics: Euclid, Archimedes, Apollonios, and Ptolemy. He developed & improved theory of amicable numbers. His theories led to development of non-Euclidean geometry. Qusta ibn Luqa (912) was a physician, astronomer and mathematician who translated Diophantos and commentaries on Euclid.

Ishaq ibn Hunain (911 Baghdad) was a renowned physician and mathematician. He translated books of 7 Greek authors including Almagest, two works of Galen into Syriac and 10 into Arabic. Abu Kamil al-Hasib al-Misri (the Egyptian mathematician) perfected al-Khawrizmi's book on algebra. Abu Usman Dimashqi flourished during the caliphate of al-Muqtadir (908-932). His noteworthy translation was Book X of Euclid and commentary on it. He translated works of Aristotle, Euclid and Galen. Ahmad al-Imrani (956) wrote a commentary on Abu Kamil's algebra. Abu Jaf'ar al-Khazin authored a commentary on the $10^{th}$ book of Euclid. Nazif ibn Yumn was a mathematician and translator who translated $10^{th}$ book of Euclid. Abul Fath Isfahani (982) was a Persian mathematician who wrote an Arabic edition of *Conics of Apollonius* and commented on the first 5 books.

Abu Sahl al-Kuhi (988) many mathematical and astronomical writing are attributed to him. His investigations into Archimedian and Apollonian problems are among the best in geometry. Abu Said al-Sijzi (1024 Sijistan) made a study of the intersections of conic sections and circles. Abul Wafa al-Buzjani (998) was one of the greatest mathematicians. He wrote commentaries on Euclid, Diophantos and al-Khawrizmi, made *Zij al-Wajih*, and a book on arithmetic Kitab al-Kamil. Abu Mahmud al-Khujandi (1000) was discoverer of sine theorem relative to spherical triangles.

Maslamaibn Ahmad al-Majriti (1007 Madrid) was a Spanish mathematician and astronomer. He edited al-Khawrizmi's Zij, wrote a treatise on astrolabe, a book on generation, two alchemical writings *Rutabat al-Hakim* (Sage's step) and *Ghayat al-hakim* (aim of the wise). Al-Biruni (1048 Ghazna) was a Persian mathematician, astronomer, encyclopedic, and philosopher. His main works were *Kitab al-Hind, Kitab Athar al-Baqiya, al-Qanun al-Masudi*. He translated several books from Sanskrit. Simplified stereographic projection similar to that first published by Nicolosi di Paterno in 1660. Sarton says: "*His critical spirit, toleration, love of truth, and intellectual courage were without parallel in medieval times*".

Ibn Tahir al-Baghdadi (1037) wrote various books on arithmetic, the most important is al-Takmil (The completion). His expertise was in solving inheritance problems. His *Kitab al-farq bain al-firaq* (on schisms and sects) was also very popular. Abd al-Rahman al-Kirmani (1066 Saragossa) was a Spanish mathematician and surgeon. Ibn al-Samh (1035 Granada) was an accomplished astronomer and mathematician. Abul Qasim ibn al-Saffar (1035 Cordova) wrote a treatise on the astrolabe and compiled a Zij. Ibn Yunus (1009 Cairo) compiled improved tables at a well-equipped observatory in Cairo which was part of *Dar al-Hikma* (1005-1171) . This was the second science academy after the one established by al-Mamun in Baghdad.

Kushyar ibn Labban (1029 Jilan) was a Persian mathematician and astronomer who composed *al-Zij al-Jami wal Baligh*, and a treatise on arithmetic. Abul Jud was a contemporary of al-Biruni. He presented Albirunic problems by means of intersecting conics, classification of equations and their reduction to conic sections.

Al-Karkhi (1029) book on arithmetic is based on Greek sources. No numerals were used in the book, names of numbers were written in full, casting out of the nines and elevens. His book on algebra *al-Fakhri* is based on Diophantos. Al-Nasawi (1030) was a Persian mathematician who wrote a treatise on practical arithmetic *al-Muqni fil Hisab al-Hindi.* It is noteworthy that he replaced sexagesimal by decimal fractions.

Omar Khayyam (1123 Iran) was a famous Iran mathematician, astronomer and poet. In fact he was the greatest mathematician of medieval times. He recognized 13 different forms of equations. His algebra contains algebraic and geometric solutions. Muhammad ibn Abd al-Baqi Baghdadi (1100) wrote a commentary on the $10^{th}$ book of Euclid, translated into Latin by Gerard of Cremona.

## 7. Astronomy

Ibrahim al-Fazari (d.777) was a renowned astronomer. He was the first Muslim to construct astrolabes. Yaqub ibn Tariq (d.796) was one of the greatest astronomers of Baghdad. He met Hindu scholar Kanka (or Manka) at the court of al-Mansur who brought with him *Siddhanta*. He wrote on the tables derived from the *Siddhanta.* (an early Indian book on astronomy).

Muhammad ibn Ibrahim al-Fazari (806) was a famous scientist and astronomer. He translated Sanskrit work Siddhanta into Arabic by the order of Caliph al-Mansur. Hindu numerals were transmitted from India to the Muslim world through this translation.

Mashallah (815) a Egyptian Jew was the earliest astronomer in Islam. He cooperated with astrologer Naubakht in the surveying the foundation of Baghdad in 762. His popular book "The twenty-seventh" was translated into Latin *De Scientia motus orbis* by Gerard of Cremona, printed in Nuremberg 1504. Al-Naubakht (776) was a Persian astronomer and engineer. He wrote a work on astrology *Kitab al-ahkam*. Fadhl ibn Naubakht (815) a learned astronomer of Baghdad was chief librarian of Caliph Harun al-Rashid. He made translations of several Persian works into Arabic.

Ahmad Nahawandi made astronomical observations in Jundishapur and compiled Zij (tables). Caliph al-Mamun constructed observatories in Baghdad and in the plain Tadmor. All kinds of observations were made under his patronage. Al-Kawrizmi was the first to compute astronomical and trigonometrical tables. Umar ibn al-Farrukhan (815) was an astronomer and an architect. He translated many works from Persian into Arabic by order of al-Mamun.

Habash al-Hasib was the first to determine the time by an altitude. He compiled a table of tangents. Sanad ibn Ali (864) was chief astronomer of al-Mamun. He constructed a Kanisa (Persian observatory) in Baghdad. Astronomical tables (Zijes) were compiled by Sanad and Yahya ibn abi Mansur. Observations were made by al-Abbas ibn Said al-Jauhari (829-830), Ali ibn Isa Asturlabi (832), Yahya ibn abi Mansur (831), al-Marwarrudhi, and al-Khwarizmi. Khalid ibn Abd al-Malik al-Marwarudhi took part in the observations made in Damascus in 832-33. His son Muhammad and grandson Umar were also reputed astronomers. Umar wrote a book on astrolabe called al-Musattah – the flattend.

Al-Dinawri made observations in Isphahan in 849-850. Asturlabi was a famous instrument make as the name implies. Al-Farghani was the first Muslim to write a treatise on astronomy, which was popular until the 15th century. It immensely influenced Muslim, Jewish and Christian astronomers.

Ahmad ibn Kathir al-Farghani (861) one of the best astronomers employed by Caliph al-Mamun. His book *Kitab fee Harakat al-samawiya wa –jawami ilm an-Najum* (Elements of Astronomy) exerted great influence on European astronomy.

Habash al-Hasib (864) made observations for 10 years 825-835, and compiled 3 Zijes – astronomical tables. After the solar eclipse of 829 he made determination of time by an altitude (of the sun), a favorite method of Muslim astronomers. One of his son Abu Ja'far ibn Habash was a distinguished instrument maker and astronomer.

*Jabir al-Battani made a number of observations in 877, and compiled a star catalogue for 880. His astronomical treatise was authoritative until the 16th century. Sines, tangents, and cotangents were used in the book. There was a table of cotangents. His Kitab al-Zij was quoted by Copernicus and many other astronomers. He also discovered the reciprocal functions of secant and cosecant, and produced the first table of cosecants. Battani discovered the secular acceleration of the moon. In 1773 Paris Academy of Sciences awarded a prize to Edmund Halley for giving an explanation of moon's secular acceleration by examining solar and lunar eclipses records made by Battani. (Sky & Telescope magazine, October 2000, page 60, USA)*

Hamid ibn Ali al-Wasiti (9th century) was foremost constructor of astrolabes. Ahmad ibn Daud al-Dinawri (895) made astronomical observations in Ispahan in 849. His important books are Kitab al-Akhbar al-tiwal (general history) and Kitab al-Nabat (Book of Plants). Ibn al-Adami (9th century) compiled astronomical tables (*Nazm al-Iqad*) which were completed by his pupil.

Ibrahim ibn Sinan (946) wrote commentaries on *Conic*s and on the *Almagest*. He wrote many papers on geometrical and astronomical subjects. Sultan Sharf al-Daula (Persia 989) built an observatory in the garden of his palace in Baghdad to observe the course of 7 planets in 988 under the supervision of al-Kuhi. Abd al-Rahman al-Sufi (986) was one of the outstanding Muslim astronomers. His work *Kitab al-kawakib al-thabita al-musawara (Book of fixed stars 964)* is in textual descriptions and pictures. He identified the Large Magellanic Cloud, it was not seen by Europeans until Magellan's voyage in the 16th century. He also made the earliest recorded observation of the Andromeda Galaxy in 964 AD; describing it as a "*small cloud*". These were the first galaxies other than the Milky Way to be observed from Earth.

Ibn al-Alam (985 Baghdad) made excellent observations. His Zij was favored during the two centuries. Al-Saghani al-Asturlabi (990 Merv) was a mathematician, astronomer and instrument maker. He was employed in the Sharf al-daula observatory.

Ibn al-Haitham (1039 Cairo) was the greatest physicist of medieval times and is considered father of optics. He was an outstanding astronomer, mathematician, physician, and commentator of Aristotle and Galen. His magnum opus *Kitab al-Manazir* (book of Optics) exerted lasting influence on men like Bacon, Kepler, and Newton. He did all his research work in a room in al-Azhar mosque. He discovered laws of refraction, and gave scientific explanation of vision. Abu Ishaq al-Zarqali (1087 Cordova) was the outstanding observer of his time. His invention of astrolabe was called Safiha. He edited the *Toledan Tables* which enjoyed much popularity.

Abdu al-Rahman al-Khazini's (1155) Zij was called *al-Zij al-Mu'atabar al-Sinjari*. His book Kitab mizan al-Hikma (1121) was one of the most remarkable books on mechanics, hydrostatic and physics.

Qutub al-Din Shirazi (1311) made enormous contributions to astronomy, mathematics, medicine, physics, music theory, philosophy and Sufism. His brilliant book on astronomy is *Nehāyat al-edrāk fi dirayat al-aflak was* completed in 1281. Kamal al-din Farsi (1319) made two major contributions to science, one on optics, the other on number theory. *Tanqih al-Manazir* is his book on The Revision of Ibn al-Haytham's Optics completed in 1309.

Ibn Shatir (1375) was famous astronomer, mathematician, inventor and engineer who worked as a timekeeper in Umayyed mosque in Damascus. Ibn Said al-Andalusi (1070 Almeria) was a historian and astronomer. He was a great observer; his observations were of great value to al-Zarqali. He is mostly famous for his book *Kitab Tabaqat al-Umam* where special attention was paid to history of science. Nur al-Din al-Bitruji

**Chronology of Muslim Scientists**

Khalid ibn Yazid (died721), al-Asmai (740), al-Khawrizmi (b780), al-Balkhi (b787), al-Fazari (b796), al-Kindi (d873), Hunain ibn Ishaq (808), Al-Dinawri (815), Thabit ibn Qurrah (836), al-Bataini (852), ibn Masawaih( 857), al-Farghani (860), al-Razi ( 884), al-Usturlabi (900), al-Sufi (903), al-Nairizi ( 923), al-Zahrawi (1013) al-Buzjani (d998), Avicenna (1037), al-Karkhi (b1019), al-Zarqali (1087), Omar Khayyam (1131), Ali ibn Ridhwan (1060), Ibn Zuhr (1162), Ibn Bajah (b 1138), al-Idrisi (1099), ibn Tufayl (b1100), Ibn Rushd (d1198), Musa ibn Maymun (b1135), al-Khazini (d1155), Abdul Latif Baghdadi (1231), Nasir al-Din al-Tusi, al-Bitruji (1202), ibn Nafis(b1288), Qutub al-din Sherazi (1311), Kamal al-Din Farsi (1320), Ibn Baitar, Abul Feda, Ibn Shater (1375), al-Jildaki( 1341), ibn al-Majid (b1351).

**References**:


1. George Satron, (1884-1956), Introduction to the History of Science, Volume I, Malabar Foundation, 1975. I gratefully acknowledge lot of information I have culled from this book.
2. Zakaria Virk, 111 Musalman sciencedan, Lahore 2011, Urdu
3. Zakaria Virk, Biography of Ibn Rushd, Aligarh Muslim University, India 2005, Urdu
4. Zakaria Virk, Biography of al-Biruni, Kitabi Duniya, Delhi, 2007, Urdu
5. Zakaria Virk, Musalmano kay shandar sciencee karnamay, Kitabi Duniya, Delhi 2009.
6. Zainurrashid Zainuddin, Muslim Scholars and Scientists, Islamic Medical Association of Malaysia- lecturer Int. Medical University, Seremban, Malaysia. No date
7. Hakim Mohammed Said, Medieval Muslim Thinkers and Scientists, Renaissance Publishing House, Delhi, 1991.
8. Robert Curley, Scientists and Inventors of the Renaissance, NY 2013
9. Various articles on the following website by the author: http://universityofkarachi.academia.edu/ZakariaVirk


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Chapter 10

# Islamic Influence on European Science

*"The Cultural influence of Islamic civilization on the Christian West affected everything from architecture to zoological research. The influence of Muslim Sciences was perhaps less apparent than that of Muslim arts. However, few if any of the scientific disciplines that began to be transformed in the West during the late medieval and Renaissance centuries could have developed as they did without the clarification, renovation, and enhancement that had been achieved by Muslim scientists"*

*(Howard Turner, Science in Medieval Islam, U of Texas Press, Austin, 1995, page 211)*

According to traditional western writers, all science and civilization is derived from Greek heritage i.e. 6th century BC to 2nd century AD. This heritage was lost during the Dark Ages i.e. 5-15th century AD, recovered during the European Renaissance -15-16th centuries, and revived for our modern world.

In order to explain how the heritage was lost for 1500 years, and recovered, it was Muslims who found it, recovered it, preserved it, and added to it from 8th to 15th century. Had the Muslims not preserved this Greek learning, it would have been lost forever. Mathematics, chemistry, physics, astronomy, geography, mechanics of 16th century bears no resemblance to that left behind by the Greeks.It was the Islamic civilization, not Greek that invented paper, printing, irrigation, windmills, farming techniques, the compass, industrial production, glass making, cotton production, trade mechanism, system of numerals 1-10, paper money and the cheque. Gardens, flowers, art of living, urban design, personal hygiene, are all products of Muslim thinkers. Western scholars gained this knowledge after Sicily, Islamic Spain were conquered, and their contact with Muslims during the 11th and 12th centuries. European scholars started translating Arabic books during the 12th century. Thus all Arabic scientific knowledge was transferred into Latin during the next three centuries.

This fact has been acknowledged by many notable historians and scholars. **John Glub** says:

"*the indebtedness of Western Christendom to Arabic civilization was systematically played down, if not completely denied. A tradition was built up by censorship and propaganda, that Muslim imperialists had been mere barbarians that the rebirth of learning in the west was derived directly from Greek and Roman sources alone, without any Arab intervention". A short history of the Arab people, London, 1969, p 289*

*Translations of Arabic works*

It is a fact that European renaissance of 12th century came about through the acquisition of scientific knowledge of Muslims by European scholars. This was achieved by translating Arabic scientific texts into Latin. It was in Spain and Sicily that majority of these translations were made. This process started in 10$^{th}$ century when French scholar Gerbert (later Pope Sylvester II 999-1003) spent three years at a monastery in Catalonia studying mathematics and astronomy from Arabic books. Toledo became the center of translation movement in the eleventh century. Two outstanding translators of this movement were Robert of Ketton, & Peter the Venerable who translated Noble Quran into Latin in 1142 AD. Several European scholars like Englishman Adelard of Bath, & Michael Scot traveled to Spain to be part of this intellectual movement. From Italy Gerard of Cremona (d1187) traveled to Islamic Spain to learn Arabic and ended up spending the rest of his life in Toledo. Gerard was to this translation movement what Hunain bin Ishaq was to 9th century translation movement of Baghdad. He translated some 71 Arabic scientific works into Latin. It was by the middle of thirteenth century that the bulk of Arabic books in mathematics, medicine, astronomy, philosophy were available in one common language of Europe, Latin.

During the 10th century, Europe began to reap the intellectual riches of the Arabs and, in so doing, to seek out its own classical heritage. The medical works of Galen and Hippocrates returned to the West by way of the Middle East and North Africa, recovered through Latin translations of what had become the Arab medical classics.

The founder of translation movement was a Spanish scholar Archbishop Raymundo (d 1151). Besides these scientific works Arabic literary genres like stories, proverb, humor, wisdom, & novels were rendered into Latin as well. In this connection famous Arabic books like *Kalilah wa dimnah, Sindbad, Barlaam and Josephaat* can be cited. The translations of these books exerted a strong influence on Spanish literature. Spanish Muslim scholar Ibn Hazm‟s book al-Tauq al-Hamama (Doves Ring) definitely influenced the European literature. Surprisingly many scholars used the word *Libro* in the title of their books, just as Muslim authors had used word Kitab (book) or *Risalah* (treatise) in the title of their works.

Levi ben Gerson (d1344) was a polymath who wrote books on astronomy, physics, mathematics, and commentaries on the Bible. He lived Avignon, France. His philosophical treatise Milhamot Adonai is in six treatises, the fifth of which is on astronomy. He presented his model of the universe based on several Arabic sources, principally al-Batani, Jabin ibn Aflah, and ibn Rushd. He invented Jacob staff, a device to measure angles. … He also employed the camera obscura, invented by al-Hazen (ibn al-Haytham) for observing eclipses and determining the eccentricity of the sun's orbit. ( john freely, Alladin's Lamp, 2009, NY, 160)

Contributions of Jewish scholars

Many Jews took part in this intellectual activity by virtue of their proficiency in Arabic, Hebrew and Latin. Abraham ben Azra (1092-1162) was one such Jewish scholar.Hundreds of books and manuals written by Muslim scientists were translated by Jewish scholars because "they moved among (diverse cultures) like fertilizing subterranean streams" ( *Durant, Age of Faith, page 910).* Moses ibn Tibbon translated Euclid's book *Elements*, as well as Avicenna's *Canon*, Razi's *Antidotary*, and Averroes commentaries on Aristotle. Hebrew medicine received stimulus through the translation of ar-Razi‟s *Kitab al-Mansuri* by Shem Tob in 1264. Ibn Zuhrs book on medicine *Taysir* was rendered into Hebrew entitled *Aid To Health* in 1280. At Toledo Archbishop Raymond organized a team of translators; many of them were Jews who knew Hebrew, Spanish, Arabic and Latin. In Sicily rulers like Charles of Anjou employed Faraj bin Salim who rendered into Latin Razi's Kitab al-Hawi as *Liber Continens*.

Translations in Sicily

Sicilian kings assumed Arabic titles; ROGER II called himself *al-Mutazz billah*, WILLIAM I was *Hadi biamrillah* and WILLIAM II was *al-Mustaeez billah*. These titles appeared on their coinage and in their inscriptions. King Roger II (111-1154) was the most illustrious ruler of Sicily. All decrees of his court were issued in three languages Latin, Greek and Arabic. The decrees which he did not sign himself bore his motto in Arabic that was based on Quranic verse 16:122. On various documents he called himself *al-Malik al-Muazzam al-Qiddis* ( the great and holy king). The crown he wore was of a Byzantine model, but his famous mantle, still preserved in Vienna, was that of an oriental emir with Kufic inscriptions embroidered on it. All his physicians were Arab Muslims, his court officials were of three faiths. (to read more on the full impact of translations on European science read: *https://www.academia.edu/6431705/Muslim_Contributions_to_European_Renaissance)*

The net effect of these translations on Western Europe was revolutionary. The influx of new books stirred the world of scholarship, compelled new developments in grammar, philology, and above all provided curriculum for the schools and universities. Theory and practice of medicine along with other disciplines was advance by these translations in various languages. A whole new range of ideas provided a new stimulus. In a nutshell these translations excited the European mind, brought about the collapse of medieval system and the dawn of Renaissance in the 15th century.

Islamic madrassas

The Greeks and the Romans had no universities in the sense in which the word has been used in the past seven or eight centuries. Universities are the product of Islamic lands of the middle ages. In Islamic madrasas a teacher (Shaikh) would sit on a chair, and students would sit on the floor forming a semi-circle (halqa). These days' Chairs are endowed in Universities which reminds us of this practice. In the medieval times an elementary school was called Maktab, while a college or university was called madrassa. A graduate from madrassa was called sahib, which became graduate in European universities. An individual teacher could attest to a student's capability by giving him Ijaza (license or doctorate).

**Abbas ibn Firnas**

**First human to fly in Cordoba in 9th century**

It is claimed that Roger Bacon of England was the first person to draw a diagram of a flying machine, and thought of human flight. Leonardo da Vinci had prepared prototypes of flying machines. The truth is Islamic Spain's engineer, inventor and aviator Abbas ibn Firnas (d.887) was the first person in history to make a flying machine in Cordoba. He made a glider (or used vulture feathers as wings) with which he flew off a hill in Cordoba and was air-born for few minutes. Upon landing he suffered injuries, because he did not have a tail on the glider, the way birds use their tail upon landing. (*Dictionary of Scientific Biography,* Vol. 1/16)

stamp issued by Spain – to honor Abbas ibn Firnas

It is said that first mechanical clock was made in Milan, Italy which was weight driven. According to Will Durant, first clock was made by Ibn Firnas in Cordoba in 9th century. Clocks were made during the time of Caliph Haroon al-Rashid, who had sent a clock as a gift to King Charlemagne of France. Europeans gained knowledge of clock making from the Latin translations of Arabic books. (*Age of Faith by Will Durant*).

Roger Bacon understood the importance of alchemy; he did not mention Jabir ibn Hayyan (815) in his works although he became acquainted with alchemy through Latin translations of Arabic works.

It is said in the West that glass mirrors were made in Venice in the 13th century. The fact is that glass mirrors were made in Islamic Spain in the 11th century. People of Venice gained the technical knowledge for glass making from Syria.


*The first page of al-Kindi's manuscript "On Deciphering Cryptographic Messages", containing the oldest known description of cryptanalysis by frequency analysis.*

**Muhammad ibn Jabir Al-Battani (Albateniu)** computed his own astronomical tables (Zij) in 10th century, translated into Latin and Spanish in 12th and 13th centuries. His *Kitab al-Zij* was translated into Latin by Plato of Tavoli. His work had large influence on scientists such as Tycho Brahe, Kepler, Galileo and Copernicus. Seven hundred years after Zij was computed, Copernicus will refer to this Zij a total of 23 times in his monumental work *On the Revolution of heavenly spheres*.

Trigonometry was a theoretical science with Greeks, but Muslims made practical use of this branch of mathematics. **Al-Batani** in fact invented basic functions such as sine, cosine and tangent. Arabic root for sine is Jaib. Similarly it is said that decimal fractions was first used by Dutch mathematician Simon Stevin in 1589. The fact is decimal fractions were used by Iranian mathematician Jamshed al-Kashi in his book *Miftah al-Hisab* (Key to Mathematics). It is also said that X & Y symbols were first used by French mathematician Vieta in 1591. Algebra was invented by Muslims who used these symbols in finding solutions of cubic equations. An unknown quantity is called shay (thing) in Arabic, it became X in Europe.

Father of Cryptography

Iraqi Philosopher, mathematician, physician, and musician **Yaqoob Al-Kindi** (873) developed frequency analysis for deciphering ancient Greek writings. Cryptography is the use of codes and ciphers to protect secrets. That is variations in the frequency of the occurrence of letters could be analyzed and exploited to break ciphers. Thus he is given the title of father of modern cryptology. He explained this in his ground breaking book *A Manuscript on Deciphering Cryptographic Messages.*

Then in his ground breaking work on medicine *Risalat fee Ma'arifat quwah al-adwiyya al Murakkabah*, translated into Latin as *De Gradibus,* Kindi demonstrated the application of mathematics and quantification to medicine, particularly in the field of pharmacology. This includes the development of a mathematical scale to quantify the strength of drugs, and a system that would allow a doctor to determine in advance the most critical days of a patient's illness, based on the phases of the moon. Kindi invented a discipline of medicine called posology, which dealt with the dosages of the drugs. Dosages for the drugs were a guessing game in the ancient world. He formulated easy to use table that pharmacists could refer to when filling out prescriptions. By documenting amounts with a mathematical formula that anyone could follow, al-Kindi revolutionized medicine. Drugs could now be formulated according to set amounts with the result that all patients would receive standardized dosages.

Encyclopedia of History of Science, Technology and Medicine in non-western cultures states: *al-kindi was contributor of new ideas trying to improve upon the knowledge of antiquity. In his work on pharmacolocy Risalat fee Ma'arifat quwah al-adwiyya al Murakkabah – he applied the principles of psology (the study of dosages). He based the efficacy (quwah) of compound medicine upon geometrical progression. He linked the degree of intensity with numerical changes in the qualitative forces that produce them. …. If a compound medicine was to be warm in the first degree it had to possess double the equable mixture. If it was to be warm in the second degree, it had to possess four times as much etc."*

**Ibn Rushd (Averroes) & Wome's lib**

Long before women's lib became popular in the world, Spanish philosopher **Ibn Rushd** (1198) advocated women rights in the 12th century. Averroes' considerations on women offer a remarkably original insight. He considers women essentially identical with men, possessing the same intellectual abilities. He advocates their active participation in society and performance of all tasks, including those that had been the prerogative of men. He urges society, in particular his Muslim contemporaries, to allow women a greater role in public affairs for the benefit of the entire state. His references to women break new ground, and prefigure important debates that would flourish in modern Europe. Averrores does not see a contradiction between this and Islamic religion. "(http://jis.oxfordjournals.org/content/20/1/1.abstract?etoc)

He firmly believed that women can be a philosopher-ruler. In his *Bidayatul Mujtahid* he says: " *Qala al-tabari yajoozu an takoona al-mira'ata hakiman ala-l- atalaq fee kullay shaye*". Women can be a judge in all litigations – civil as well as criminal. (Volume 2, page 277). Because of such ideas we can see in our age how many women have won Nobel prizes, and contributed significantly in all fields of sciences. He said women may practice crafts as they are weaker at some and more diligent at others. They may be warriors. He made it clear that subordination of women in his own society was wrong, based on ignorance, and contributed to economic backwardness.

Muslims not only influenced European scholars with their inventions, discoveries, science theories but with their powerful ideas as well which produced a paradigm shift in their weltanschauung. Averroes Latin translations and commentaries paved the way for Renaissance. European scholars became acquainted with Ibn Rushd ideas through the deep study of his books. His books were included in the syllabus of Paris University and other Western universities till the advent of modern experimental sciences. He was studied in the University of Mexico until 1831.

Christiane Klapish-Zuber writes: "*In the second half of 13th century the conjunction of Aristotle's philosophy with Averroes not only inspired new works in theology but also encouraged a naturalistic outlook and a more liberal latitude toward sexual behaviour*. "(A History of Women, London, 1992, page 45)

Further on she observes: *"In the West uterus was at first depicted as bicornate. Arabic medical texts gave a more accurate description: the womb was said to resemble bladder, but attached to it were two lateral tubes that supplied blood and pneuma*". (A History of Women, page 51)

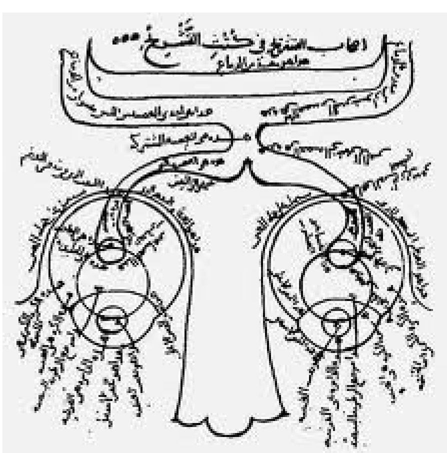
From 13th to 16th century **Ibn Rushd** religious and scientific ideas were hotly debated with the result that even Church authorities were forced to change their views on certain topics. In his book *Kashf anil Manahij* Averroes presented convincing proofs for the existence of God. Later similar proofs were found in Thomas Aquinas book *Summa Theologica*. Sir Thomas Arnold has this to say: "*The Angelic doctor has made use of many of the arguments which the Muslim doctor had previously employed".* (*Legacy of Islam*, page 276)

He influenced Western thought from the twelfth to the sixteenth centuries. In the 13th century people believed that human soul hovers over the grave after death, and that in hell soul will suffer bodily chastisement. Because of Ibn Rushd views scholars started to believe that soul is separate entity from the body, and that it will suffer spiritual chastisement not bodily. French philosopher Descartes (1650) learnt this fact from ibn Rushd that body and spirit are separate and independent entities. (Biography of ibn Rushd in Urdu by Zakaria Virk, Aligarh Muslim University, India, 2005)

Prof. Vern Bullough of State University of New York writes in his book *Medieval Scholastics and Averroism*, : " *Averroes developed a theory of color which held that colors were attributed to the presence in varying degrees of two pairs of opposite qualities: brightness and obscurity, bounded and unbounded*". Sir Isaac Newton developed his theory of colour in light of this observation.

Giles of Rome (1247-1316) was the first person who authored first work on embryology and systematically discussed when spirit enters the human body. Ibn Rushed believed that spirit and body are born at the same time, but it shows its presence when the baby starts moving. This view was accepted by the Church in the 19th century.

Was Galileo influenced with the scientific ideas of Ibn Rushd? Prof Nicholas Rescher writes: *" The Averroist tradition of Padua kept alive the Arabic interest in and spirit of inquiry respecting natural science, until the time that it provided intellectual grist to the mill of Galileo and his teachers*: (*Studies in Arabic Philosophy, University of Pittsburgh press, 1966, page 153)*



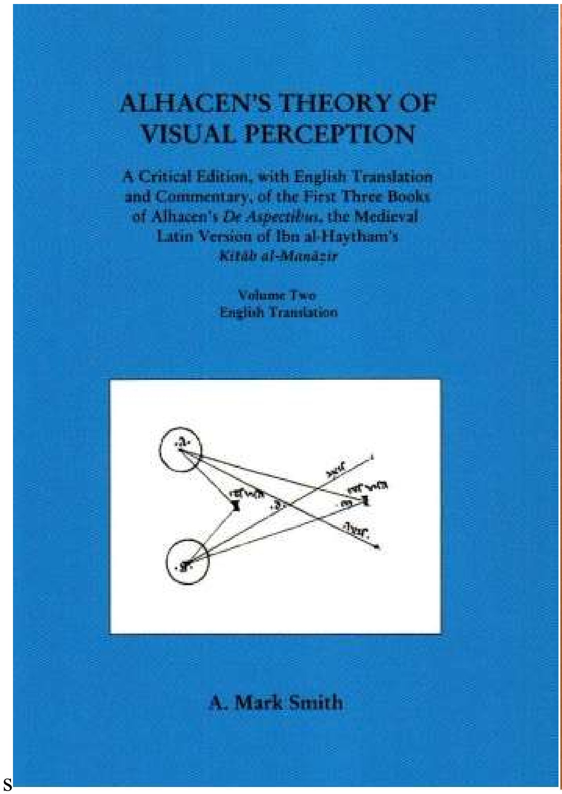
Alhazen description of the eyes

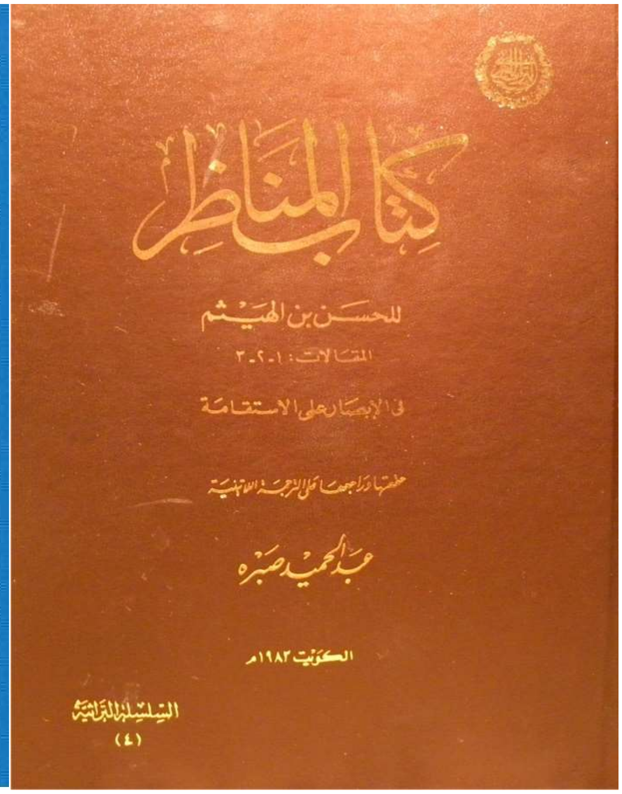
**Ibn al-Haitham** did extensive investigations on light, lenses and camera obscura. In fact he invented the pin-hole camera. It is said that Newton was the first person to have stated that white light consists of various colours. The fact is that this discovery was made by ibn al-Haitham and Kamaluddin Farsi, who prepared an edited version of *Kitab al-Manazir*, *Tanqih al-Manazir*. In Newton's personal library a copy of Kitab al-Manazir in Latin translation was found.


Haitham, on a bank note. 10 Iraqi Dinar

His law of refraction was rediscovered by Dutch scientist Willebrod Snell (1591-1626) and is now called, Snell‟s law, N1SIN1=N2SIN2. As a prolific author he wrote close to 200 books, few have survived through Latin translations. In mathematics he solved problems involving congruence's using what is now called WILSON's theorem.

In 1795 Scottish mathematician John Playfair (1748-1819) published an edition of Euclid's famous book *Elements* in which he gave an alternative to Euclid's parallel postulate which is now called PLAYFAIR's Axiom. This alternative was in fact discovered by Ibn al-Haisham more than 1000 years ago when he stated: *" al-khatane al-mustiqee mane al-mutaqate aane la yo-waziyan khataa wahidaa mustaqeemaa ."* This should have been called Alhazen‟s Axiom but Western scholars are not shy of such intellectual dishonesties.





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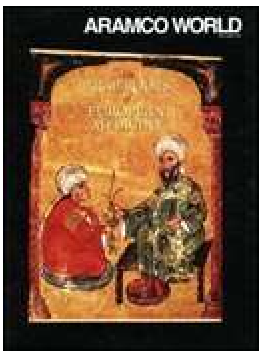
Latin translation of Book of Optics, a copy was found in Newton's personal library.

**Shaikh al-Raees- Ibn Sena (Avicenna)**

Prince of physicians **Ibn Sena** (d.1037) discussed how to deal with a fracture to the metacarpal bone in the thumb, which modern books describe as "Bennett's fracture", named after the man who supposedly discovered it in 1882, nearly 900 years after Ibn Sena. (*House of Wisdom, by Jim al-Khalili, NY 2011, page 179*). Ibn Sina's *Canon* was copied then recopied, & became the standard European medical reference work for 500 years. In the last 30 years of the 15th century, just before the European invention of printing, it was issued in 16 editions; in the century that followed more than 20 further editions were printed. From the 12th to the 17th century, its *materia medica* was the pharmacopoeia of Europe, and as late as 1537 *The Canon* was still a required textbook at the University of Vienna. For more information read https://www.academia.edu/6527080/Canon_of_Medicine_of_Ibn_Sena_-_its_translators_and_commentators

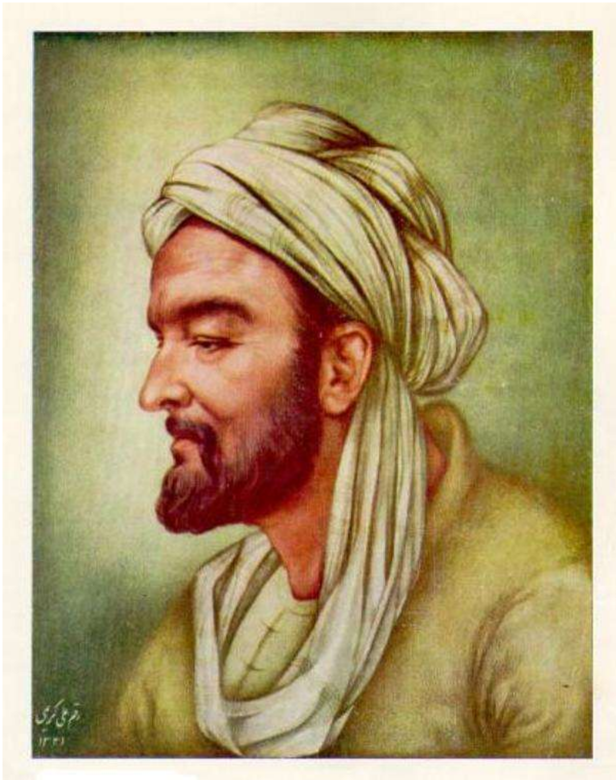
Lectures at Montpellier up to 1555 continued to be given upon the text-books of Razi-Rhazes, ibn Sena- Avicenna and the two Mesues. In 1558 Saporta, the doyen of the Faculty of Medicine of Montpellier University, was still lecturing upon the Razi's al-Mansuri -*Libre Nonus ad Almansorem*. In the University of Brussels by some curious oversight, the lectures upon Avicenna survived until 1909.

In so far as Ibn Sena's contribution to Scholasticism is concerned; i.e. a medieval western Christian philosophical system solving problems such as faith and reason, will and intellect, realism and nominalism, and the provability of the existence of God. Howard Turner writes: "Ibn *Sena's all-embracing vision, took affect far beyond Islam, ultimately influencing the evolution of the scholastic philosophy that dominated the medieval theological philosophy of the Christian West." (Turner, Science in Medieval Islam, page 22)*



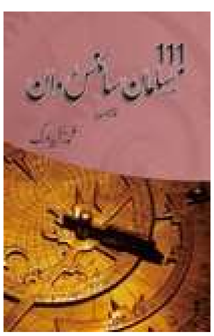
Arab Physician

Book 5 of ibn Sena's Kitab al-Qanoon, Dated: **1052**, Materials and Technique: Opaque watercolour and ink on paper. Qanun was translated into Latin in Toledo, Spain, in the thirteenth century. It then became the most influential medical encyclopedia in Europe, where it was taught in universities well into the eighteenth century. Copy at Aga Khan Museum, Toronto




Kuwait

Iranian scientist **Zakariyya al-Razi** (925) introduced controlled experiment and clinical observation in medicine. He carried out the earliest known example of a clinical trial employing a control group. Razi began by selecting two sets of patients, all of whom are showing early symptoms of meningitis. He then treated one group with bloodletting, but not the second. He writes that 'by doing this, I wished to reach a conclusion (on the effectiveness of bloodletting) and indeed all those of the second group contracted meningitis'. (*Jim al–Khalili, The House of Wisdom, , London, 2011 p. 147*) He was laying the foundation of what in allopathic medicine will be called controlled studies, which is the favoured way of investigating any therapy in this day and age. He is regarded as father of pediatrics on account of his treatise *The Diseases of the Children.* His work on kidney stones is still considered a classic.




Zakaria Virk's book "111 Muslim Scientist- medieval and contemporary'. (Urdu-2013)

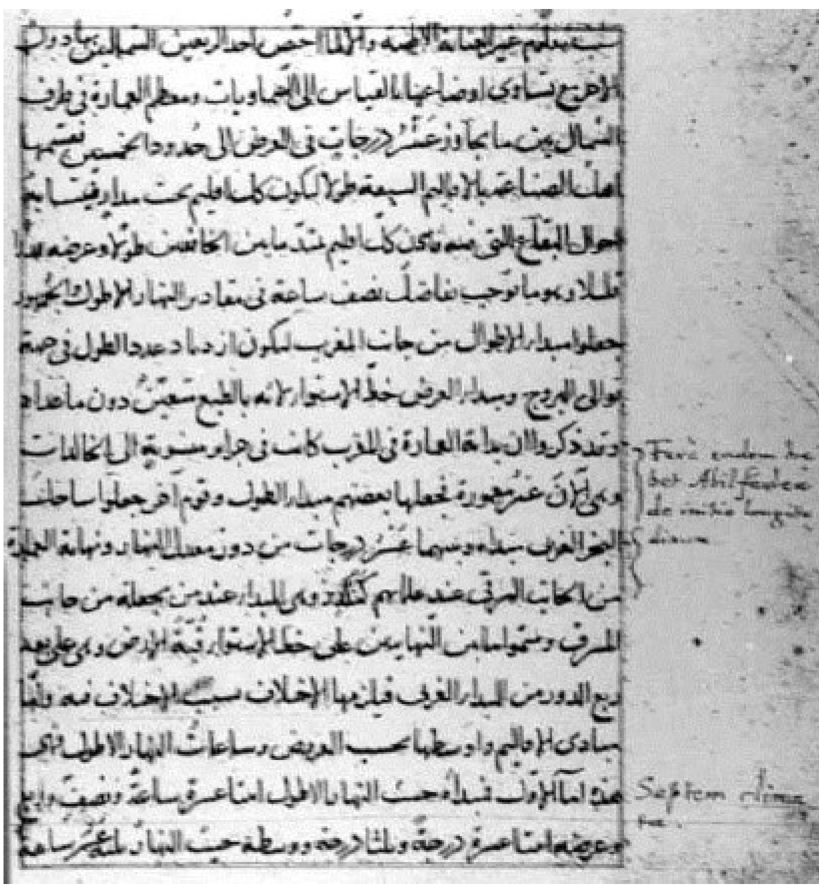
It is said logarithm tables were invented by John Napier in 1614, but this is a Muslim invention.

**Omar Khayyam** made a significant contribution in mathematics called Binomial coefficients, but in Europe it is called *Pascal's triangle*.

1
1 1
1 2 1
1 3 3 1
1 4 6 4 1
1 5 10 10 5 1

The binomial coefficients can be arranged to form Pascal's triangle.

Persian astronomer **Nasiruddin Tusi** (1274) developed a mathematical device called *Tusi Couple*. Zauj-Tusi was used by Nicolaus Copernicus (d.1543) in his reformulation of mathematical astronomy. Al-Urdi theorem was developed by Muay al-din al-Urdi in 1250. The same theorem was found in Copernicus (Mikolaj Kopernik, in German) master piece on astronomy.



Tusi book on astronomy

Tusi (d.1274) developed a special geometrical construction in connection with Euclid's fifth postulate, which was used by England's John Wallis (d.1703) in his researches. Subsequently this technique was used by Saccheri (d.1733), but both of them did not give credit to Tusi.

For his planetary models, Tusi invented a geometrical technique called **a Tusi-couple**, which generates linear motion from the sum of two circular motions. He used this technique to replace Ptolemy's problematic equant for many planets, but was unable to find a solution to Mercury, which was solved later by Ibn al-Shatir as well as Ali Qushji. The Tusi couple was later employed in Ibn al-Shatir's geocentric model and Nicolaus Copernicus' heliocentric Copernican model" (Wikipedia article Tusi)

Kitab Suwar al-Kawakib al-Thabite – A book of images & fixed stars by Sabit ibn Qurra, 9th century Baghdad, copy at the Aga Khan Museum, Toronto (photo by Zakaria Virk Oct 12. 2014)

Syrian astronomer **Allauddin ibn Shatir** prepared a model of moon and mercury, which was later found in Copernicus book, *De revolutionibus orbium coelestium*.

**Jabir ibn Aflah** (Seville 1100–1150) was Islamic Spain's renowned astronomer and mathematician. He used trigonometry in solving some highly complex problems. Astonishingly same solutions were found in Johann Mueller book in 1464. This intellectual theft was discovered by Italian mathematician G. Cardano (d1576). Jabir's book had influenced scores of Muslim, Jewish and Christian astronomers. After reading Jabin ibn Aflah's book *Islah al-Majisti* (*Corrections to Majisti*), Copernicus criticised Ptolemy's system of Universe and presented a new model in which Sun was in the centre- i.e. heliocentric.

**Abu Bakr Ibn Baja** (Avempace d.1138) was polymath, astronomer, philosopher, physician, physicist, and a scientist of highest calibre. He was predecessor of Copernicus who rejected Ptolemaic planetary model in Europe. He provided intellectual nourishment to Aquinas (1274), Dun Scotus (1308), and smoothed the way for Copernicus, Tycho Brahe and Galileo to have the courage to reject Ptolemaic system as well. Once their line of thought was changed, it became easier to accept the heliocentric system. John Freely writes, " *Ibn Baja seems to have been the first Arab scientist in Andalus to oppose the Ptolemaic planetary model." (Alladin's Lamp, Vintage Books, NY, 2010, page 119)*

One of his theories of motion goes like this: In the absence of a medium, the body would move with its original velocity. Velocity would decrease in proportion to the resistance of the medium". (*Dictionary of Scientific Biography, Vol 1, NY 1972, page 409*) **Ibn Baja** was the first person who said -to every action there is reaction, which became Newton's 3rd law of motion. Titus Burkhardt has described two theories of ibn Baja in his book

"Physics of ibn Baja were reaching Galileo by way of writings of Averroes. His is the well-known formula whereby the speed of a moving body is equal to that of the moving force, less the environmental resistance. He is likewise the author of the important thesis that the force that causes a fruit to fall from the tree is the very same as that which moves the celestial bodies". (*Moorish Culture in Spain, 1972, NY, p166*).

Galileo learnt a lot from theories of ibn Baja. This is quiet common in the scientific field as scientist base their theories or discoveries on theories of their predecessors. No point inventing the wheel. It is good to move on where someone left it off. On this point al-Kindi rightly observed, " *we ought not to be ashamed of applauding the truth, nor appropriating the truth from whatever source it may come, even if it be from remote races and nations alien to us. There is nothing that beseems the seeker after truth better than truth itself".*

Following quote augments our assertion: "*Moody shows that Galileo's law was enunciated many centuries before by Avempace, a Spanish Arab whose views were transmitted to the Latin west in the commentary of Averroes on Text 71, of Book IV of Aristotle's Physics... it seems that not only was Galileo's law derived from Avempace and Philoponus, but it was in fact identical with the law expressed by his predecessors*." (*Edward Grant, Studies in Medieval Science, London 1981, page* 80).

In his other book *A source book of Medieval Science*, Grant writes," *In the case of physics, one may recall the originality of Ibn Baja, whose commentary on Aristotle regarding the dynamics of motion is in a direct path leading to Galileo's theory of free fall".* (Harvard University Press, 1974 USA).

**Ibn Bajja** (d.1138) discovered law of motion: *speed of a moving object is equal to moving force. He also postulated that the force that keeps the planets in their orbits is the same that makes an apple to fall to the ground*. Galileo after studying Ibn Baja's theories rejected Aristotle's view that speed of a body is proportional to its weight.

It is stated in **Wikipedia**: "*in Islamic physics, Ibn Bajjah's law of motion was equivalent to the principle that uniform motion implies absence of action by a force. This principle would later form the basis of modern mechanics and have a subsequent influence on the classical mechanics of physicists such as Galileo Galilei. Ibn Bajjah's definition of velocity was also equivalent to Galileo's definition of velocity:……….Velocity = Motive Power – Material Resistance*

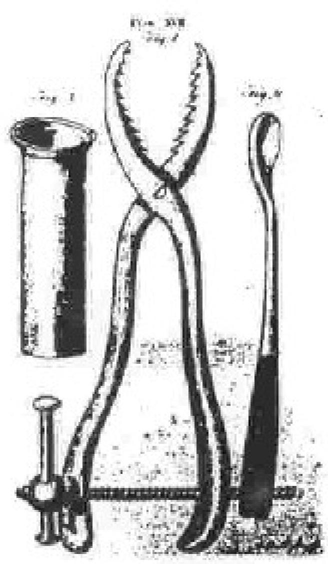
**Abul Qasim al-Zahrwai**

Islamic Spain's greatest medieval surgeon **Abul Qasim al-Zahrawi** (d.1013) described in his book *Kitab al-Tasrif* modern clinical techniques i.e for treating a dislocated shoulder (now called Kocher's method) and simplifying difficult labours now called Welcher's position.

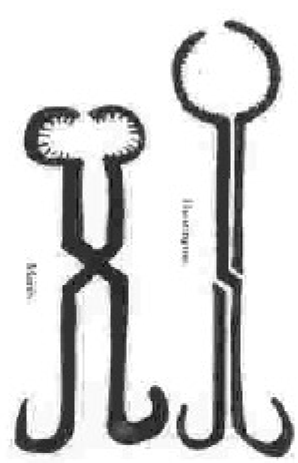
He was the first to illustrate the various cannulae and the first to treat a wart with an iron tube and caustic metal as a boring instrument. He was also the first to draw hooks with a double tip for use in surgery. He described how to ligature blood vessels almost 600 years before Ambroise Paré. Al-Tasrif was the first recorded book to document several dental devices and explain the hereditary nature of haemophilia. He described the use of forceps in vaginal deliveries & introduced over 200 surgical instruments. Many of these instruments were never used before by any previous surgeons. His use of catgut for internal stitching is still practised in modern surgery.

Donald Campbell, a notable historian of Arabic medicine, described **Al-Zahrawi's** influence on Europe as follows: "*The chief influence of Albucasis on the medical system of Europe was that his lucidity and method of presentation awakened a prepossession in favour of Arabic literature among the scholars of the West: the methods of Albucasis eclipsed those of Galen and maintained a dominant position in medical Europe for five hundred years, i.e long after it had passed its usefulness. He, however, helped to raise the status of surgery in Christian Europe; in his book on fractures and luxations, he states that 'this part of surgery has passed into the hands of vulgar and uncultivated minds, for which reason it has fallen into contempt.' The surgery of Albucasis became firmly grafted on Europe after the time of Guy de Chauliac (d.1368)."* Campbell, Donald (2001). *Arabian Medicine and Its Influence on the Middle Ages: Trubner's Oriental Series*. London: p. 88

Zahrawi

By ANDREAS A CROCE

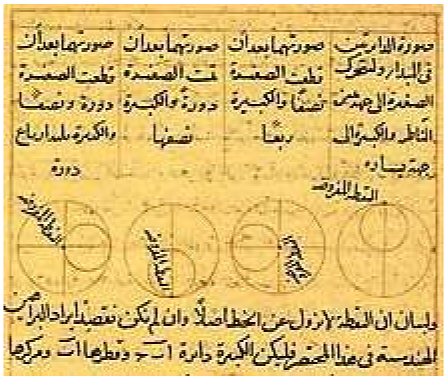


By ALBUCASIS

LITHOTRITE

Page from a 1531 Latin translation by Peter Argellata of El Zahrawi's treatise on surgical and medical instruments.

French surgeon Guy de Chauliac (1368) quoted *al-Tasrif* over 200 times in his tome. Pietro Argallata (d. 1453) described Abū al-Qāsim as "*without doubt the chief of all surgeons*". Zahrawi's influence on European medicine continued for at least five centuries, extending into the Renaissance. His book on cauterization, incision, venesection and bone-setting is available online: http://books.google.ca/books?id=mjVra87nRScC&pg=PR5&redir_esc=y#v=onepage&q&f=fals


Tusi Couple (Zauj-e-Tusi)


In February 2013, Google celebrated his 812th birthday with a doodle, which was accessible in its websites with Arabic language calling him *al-farsi* (the Persian).

Baghdad's 9th century mathematician, astronomer, physician and translator **Thabit ibn Qura** (d.901) discovered an equation for finding the amicable numbers. Seven hundred years later Franc's Pierre Fermat (d.1665) used a similar formula to find second pair of amicable numbers, but did not bother to give credit to Thabit ibn Qurra. According to Copernicus Thabit determined the length of the sidereal year as 365 days, 6 hours, 9 minutes and 12 seconds (an error of 2 seconds). Copernicus based his claim on the Latin text attributed to Thabit.

Persian polymath, physician, & chemist **Zakariya al-Razi** (d.925) stated that characteristics of sulphur, salt and mercury are found in almost everything. The same discovery was made by Swiss physician Paracelsus (1541) in Europe. Some volumes of Razi's multi-volume work *Kitab Al-Mansuri*, namely "On Surgery" and "A General Book on Therapy", became part of the medical curriculum in European Universities. His tome about smallpox and measles *al-Judri wal-Hasba* provided clinical characterization and was the first book on this topic. The ninth book of *Al-Kitab al-Mansuri* ("Concerning Diseases from the Head to the Foot") remained part of the medical curriculum at the

University of Tübingen until the end of the 15th century. His medical works, novel ideas and discoveries profoundly influenced the West for hundreds of years. In the Medical School of University of Paris, there hang portraits of two giants of Islamic medicine namely Razi and Ibn Sena, paying homage to these outstanding doctors. In the $13^{th}$ century the curriculum of Paris Medical School consisted of 9 books of Razi and Ibn Sena.

**Ibn al-Haitham** stated that when light passes through a medium, it takes the easiest and fastest path to travel. In Europe it is referred to as Fermat's *principle of least time*. (*Ideals and Realities* by Dr Abdus Salam, 1989).


al-Jazari

Turkish inventor, and father of robotics, **Badi- u- Zaman al-Jazari** (d.1206) invented combination lock, it appeared in England in 17th century. Al-Jazari's inventions later appeared in Europe, including conical valve, patented in England in 1784. His monumental work on mechanical devices '*A book of Ingenious devices*' he mentioned valves and pistons. He is considered to be father of robotics. He invented more than 50 automatic devices. He invented crankshaft which is essential to so many modern machines. The Elephant Clock was one of the most famous inventions of Al-Jazari, a replica is found in Dubai Shopping Mall. The seven meters high clock uses Greek water raising technology, an Indian elephant, an Egyptian phoenix, Arabian figures, Persian carpet, and Chinese dragons, to celebrate the diversity of the world. In his water pump to raise water he used pistons, paddles and camshaft, crank connecting rod system, forcing water up through pipes and out to city streets. Crank connecting rod is used in bicycles also. He invented water wheels with cams on their axle used to operate automata. He described a hand washing.

Elephant clock – replica in Dubai Mall


Astrolabe displayed at Aga Khan Museum, Toronto (credit Zakaria Virk Oct. 12, 2014)

Syrian doctor **Allauddin ibn Nafis** (d.1288) described function of pulmonary circulation of blood in 13th century, 300 years later Michael Servetus (d.1553) and then William Harvey were credited with this discovery.

German astronomer Regiomontanus wrote a book on Trigonometry- *De Triangulus*, 4th part of this book is stolen from **Jabir ibn Aflah's** (d.1150) work. I quote the following from Wikipedia: "*Much of the material on spherical trigonometry in Regiomontanus' On Triangles (c.1463) was taken directly and without credit from Jābir's work, as noted in the 16th century by Gerolamo Cardano*." The trigonometry that Nicholas Copernicus (1473–1543) outlined in the first part of his epochal work De revolutionibus was also apparently inspired by Jābir.

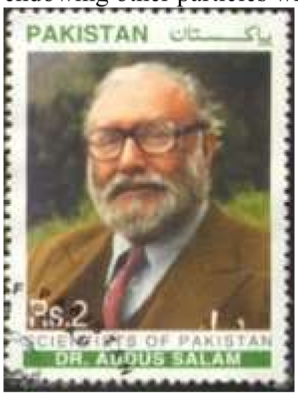
Jabir's theories on astronomy and physics were preserved by Maimonides and Averroes in their commentaries, which had a deep influence on later astronomers and physicists in the Islamic civilization and Renaissance Europe, including Galileo.

A Muslim scholar from Tunisia Abul Hassan converted to Christianity and took the name of Constantine **the African** (1010-1087) He was born in Carthage, moved to Salerno, before retiring in 1076 to Monte Cassino. There he spent his remaining years in great activity; among the 30-odd medical works attributed to him are translations of Hippocrates, Galen, Isaac Judaeus, and Ali Abbas (Haly Abbas). Of the many Arabic books he translated into Latin, he put his name as their author. He outstripped many in plagiarism.

The tides on the Earth are mostly generated by the Moon's gravitational pull from one side of the Earth to the other, the tidal forces. According to Phillip K. Hitti this was first described by Abu **Mashar Balkhi**, however the credit is given to Kepler.

I would like to end this short but insightful article by giving a quote from a book :" *Razi's physics consisted, as far as its principles were concerned, of fundamental ideas which, given the different level of scientific knowledge, were* *similar to surprising extent to those of Newton's system*" ( Arabic Versions of Greek Texts, and in Medieval Sciences by **S. Pines**, EJ Brill, Leiden, 1986, p 197)

**Dr. Abdus Salam** (1996 Oxford) He was the first Pakistani and Muslim to win the Nobel laureate in Physics for his work in Electro-Weak Theory. Salam, Sheldon Glashow and Steven Weinberg shared the prize in 1979 for this discovery. Salam and Steven Weinberg independently anticipated the existence the 'God particle' which later became formally known as the Higgs boson after the British professor Peter Higgs which is responsible for endowing other particles with mass.




**Ahmed Hassan Zewail** (b.1946) is an Egyptian scientist who won the Nobel Prize in Chemistry in 1999 – the first of his race to win such accolade in the field of Science. He is known to be the Father of femto-chemistry because of his marvelous works in the area of Physical Chemistry.

**References:**

John Glubb, A short history of the Arab people, London, 1969, p 289
*2. Dictionary of Scientific Biography,* Vol. 1/16
3. Will Durant, *Age of Faith,*
*4.* Encyclopedia of History of Science, Technology and Medicine in non-western cultures
5. Thomas Arnold, *Legacy of Islam*, page 276
6. Zakaria Virk, Biography of ibn Rushd in Urdu, Aligarh Muslim University, India, 2005
7. Nicholas Rescher, *Studies in Arabic Philosophy, University of Pittsburgh press, 1966, page 153*
8. *Jim al–Khalili, The House of Wisdom, , London, 2011 p. 147*
9. Zakaria Virk, 111 Muslim Scientists in Urdu, Lahore 2013
10. John Freely, Alladin's Lamp, Vintage Books, NY, 2010, page 119)
11. Titus Burkhardt, *Moorish Culture in Spain, 1972, NY, p166*).
12. Edward Grant, Studies in Medieval Science, London 1981, page 80
13. E. Grant, A source book of Medieval Science, Harvard University Press, USA 1974
14. Campbell, Donald, *Arabian Medicine and Its Influence on the Middle Ages: Trubner's Oriental Series*. London: 2001, p. 88
15. Dr. Abdus Salam, Ideals and Realities by Dr Abdus Salam, 1989).

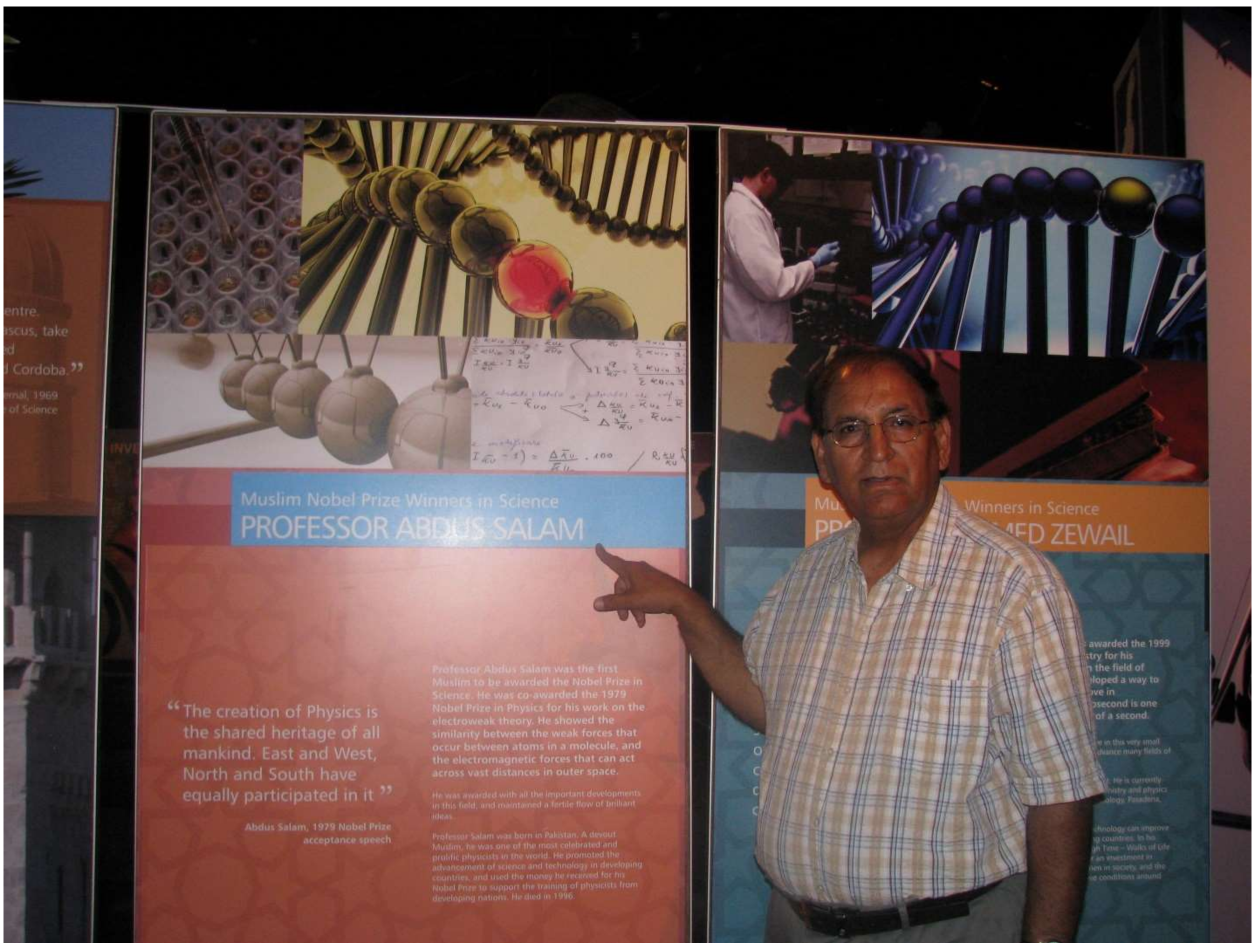
16. S. Pine, Arabic Versions of Greek Texts, and in Medieval Sciences by **S. Pines**, EJ Brill, Leiden, 1986, p 197)

**Sultans of Science Exhibition – 1000 years of knowledge rediscovered**

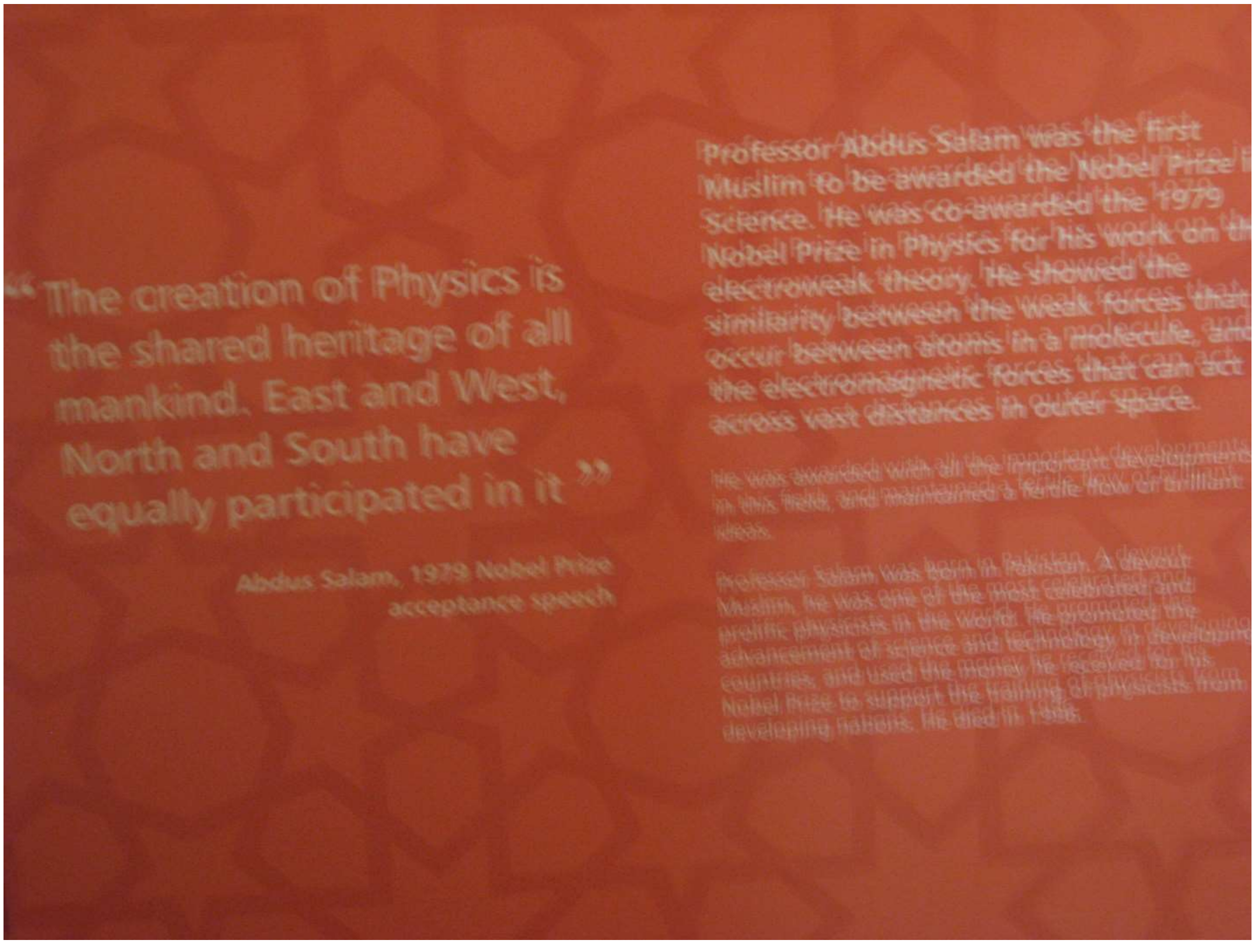
Sultans of Science Exhibition took place in Toronto in August 2014 at the Ontario Science Centre. It exhibited the history behind scientific inventions, scientific theories from the Golden Age of Islamic Science (8th to 12th centuries) were displayed in nine different exhibition areas, focusing on Muslim mathematics, astronomy, surgery, medicine and more. There were hands-on learning areas for kids such as using blocks and geometric shapes recreate structures; learning mathematics with modern day numbers versus Babylonian, Arabic and Roman numbers; discovering optical illusions and using old compasses and navigation tools. To look at some of the pictures please click on the following:

http://www.toronto.com/articles/inside-sultans-of-science/

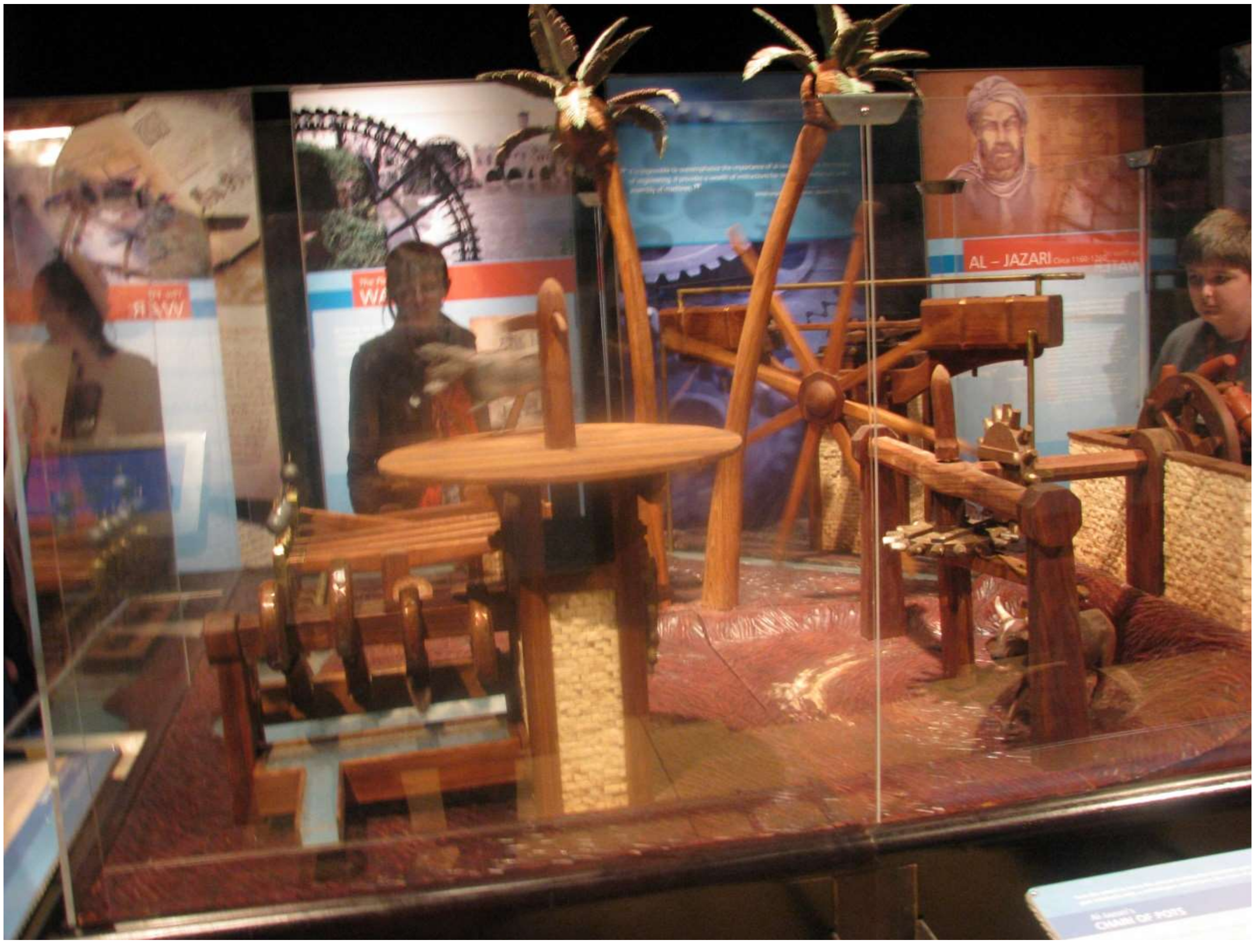
A replica al-Jazzari's impressive famous Elephant Clock was right at the entrance. In order to pay homage to two to modern day Muslim scientists, two posters were erected for Nobel laureates Dr Abdus Salam (1979) and Dr Ahmad Hassan Zewail. (1999)




Author of this article with the poster of Prof. Abdus Salam at Sultans of Science Exhibition



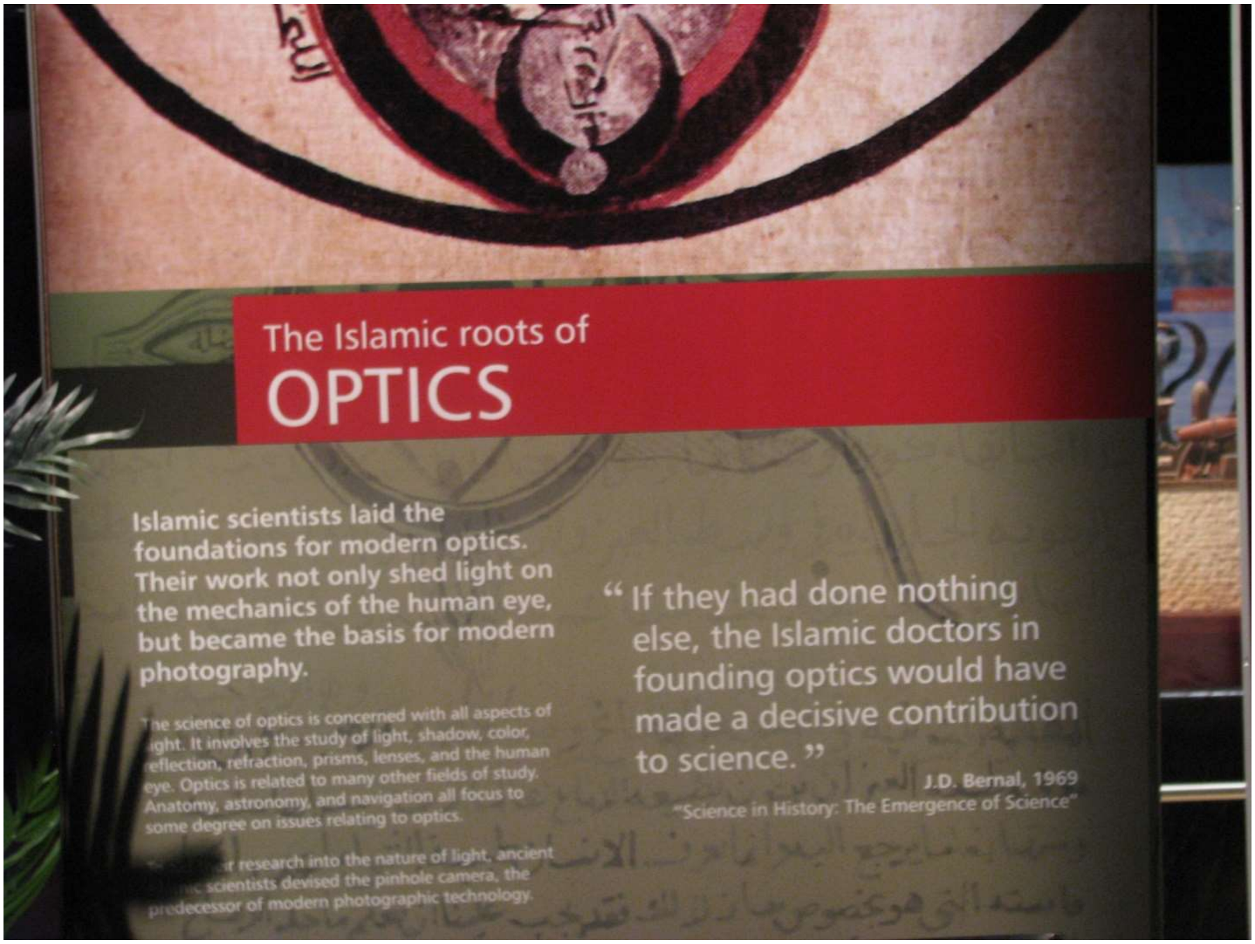

Eye-catching Poster about Muslim world's first Nobel laureate Dr Abdus Salam at the Exhibition, with one of his famous saying highlighted "*The creation of Physics is the shared heritage of all manking. East and West North and South have equally participated in it"*




Various machines invented by Turkish polymath al-Jazari

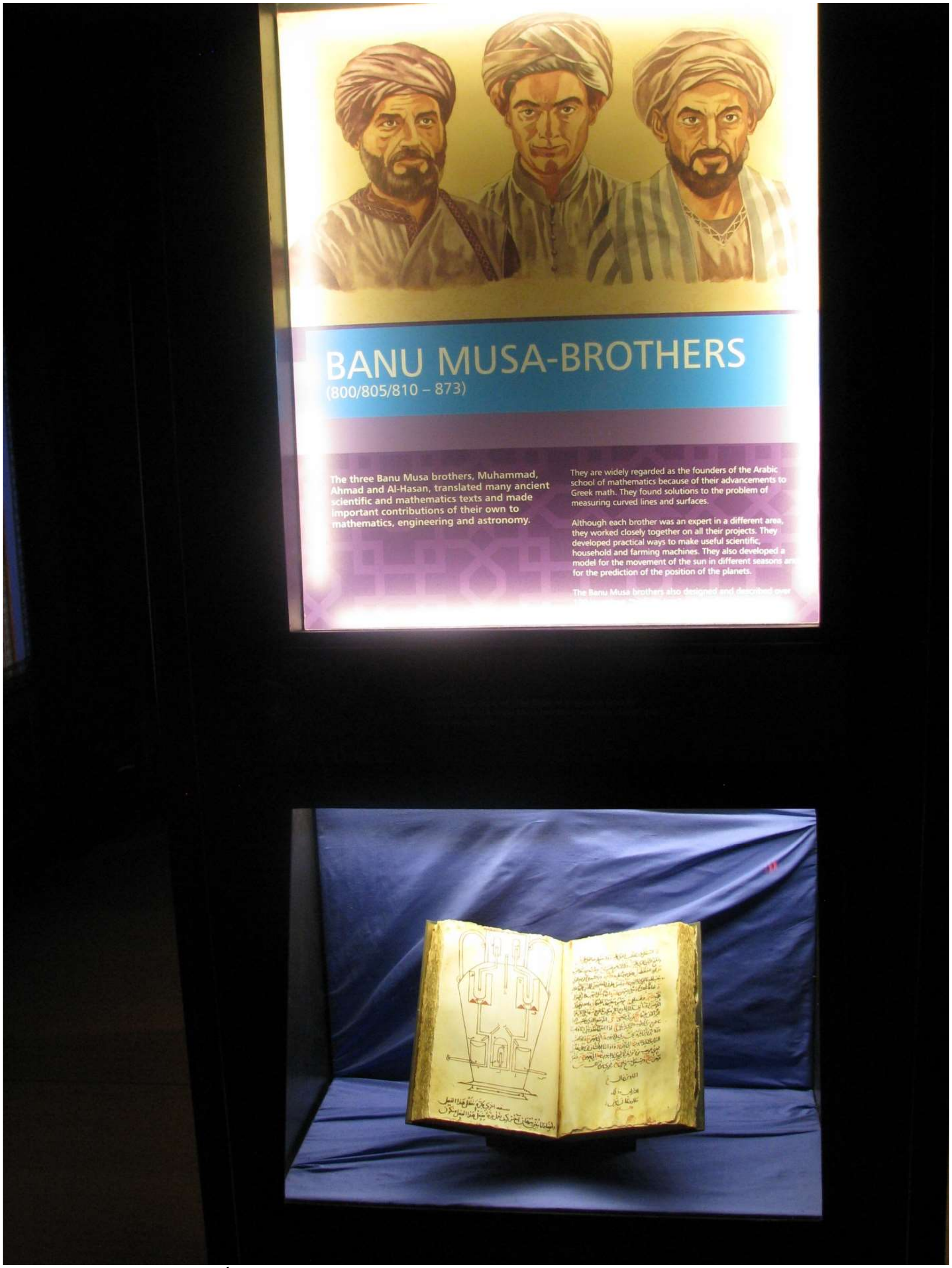
Abbas ibn Firnas with his flying machine, the first person in history to fly in Cordoba

Manuscript of an old Arabic book on astronomy, probably al-Biruni’s Book on Shadows



Islamic roots of Optics – read carefully the saying of Prof J.D. Bernal

Abu Rehan al-Biruni, a distinguished scientist from Afghanistan, with his book on astronomy




three brother scientists of 9th century Baghdad with a copy of their book on Mechanical Devices

Chapter 11

# Science in India during the Muslim Rule

*Islamic World welcomed Christians and Jewish students equally with Muslims, not only that, but entertained them at the Government expense and that hundreds of Christian students from South of Europe and the countries of the East took advantage of that chance to escape from ecclesiastical leading strings; we can easily perceive what a debt of gratitude modern European progress owes to Islam, while it owes nothing whatsoever to the Christian Church, which persecuted, tortured, even burnt the learned.*

(Marmaduke Pickthall, The Cultural Side of Islam, Lahore, 1969, p 76)

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The scientific cooperation between India and the Arabs dates back to the time of Abbasid Caliphate of Baghdad when a number of books on astronomy, mathematics, and medicine were translated from Sanskrit into Arabic. From then on the ancient scientific knowledge of India continued to influence Muslim scientists. Arab interest in Hindu sciences was parallel to their interest in Greek learning.

When Sind was under the dominion of Caliph al-Mansur (753-774), there appeared before him a scholar who had come from India. He was skilled in the calculus of the stars known as Sindhind (i.e. *Siddhanta*), and possessed methods for solving equations founded on the kardagas (i.e. sines) calculated for every half degree, also methods for computing eclipses and other things. Al-Mansur ordered the book *Brahma-siddanth*a in which all this contained to be translated into Arabic, and that a work should be prepared from it which might serve as foundation for computing the motions of the planets. This was done by Ibrahim al-Fazari (d770) and Yaqub Ibn Tariq (d796) in cooperation with Hindu pundits in 750 and the book was called *Al-Zīj ʿalā Sinī al-ʿArab, or Sindhand al-Kabir*. (1**)** In fact the Hindu scholars had brought two books with them.

This Siddhanta translation was possibly the vehicle by means of which the Indian numerals were transmitted from India to Baghdad. With the help of these Hindu Pundits, Al-Fazari, translated Brahmagupta's other book *Khandakhadyaka* and gave it the Arabic name of A*rkand*. Both works were extensively used, and exercised great influence in the development of astronomy in the Islamic world. It was on this occasion that the Arabs first became acquainted with the Hindu system of astronomy. They learned astronomy from Brahmagupta (d.668) earlier than Alexandrian scientist Ptolemy.

The Greek and Sanskrit texts on mathematics and astronomy were used by Muslim scientists as bedrock to develop new fields. Hindu mathematics left a more lasting impression on the Arab sciences. What we call today Arabic numerals, were in fact Indian numbers. The Arabic word for numbers is *Hindsah*, which means from India. This way of writing numbers, including the way to write a 'zero', was very exciting to mathematicians. Arab scientists in Iraq, especially Muhammd ibn Musa al-Khawrizmi (d.840) used the new numbers to develop algebra around 830. The English word algorithm is derived from his name. Some mathematical and astronomical terms were borrowed from Sanskrit. Ethical writings of Chankya (Shanaq) and works on logic and magic were translated as catalogued by ibn Nadim in his 10th century *Kitab al-Fihrist.* Ibn al-Muqaffa translated *Pancatantra* into Arabic as *Kalila wa Dimna*. The fascinating story of Sindbad was partly of Indian origin. Parts of *Mahabharata* were rendered into Arabic by Ali Jabali, c.1026. **(2)**

A large number of Sanskrit medical, pharmacological and toxicological texts were translated into Arabic under the patronage of Khalid Barmaki, the vizier of Caliph Al-Mansur. Indian medical knowledge was given a further boost under Caliph Harun al Rashid (786-809) who ordered the translation of *Susrata Samhita* into Arabic. For over five hundred years Muslim & other writers continued to apply to works on arithmetic the name Indian. Prime Minister Yahya bin Khalid Barmaki deputed ambassadors to India to invite distinguished scholars, physicians, & philosophers to Baghdad. In appointing translators, the Caliph made no distinction of creed or color.

The Muslims were very keen on informing themselves of the customs, sciences, and religions of the people whom they came into contact with. Yaqoob Kindi's (873) account of India was based on the evidence of the envoys sent to India to procure medicines and to report on Indian religions. Ali Ibn Hyusayn Masudi (956) visited India and wrote about Hindu beliefs, their history from legends, and complimented them on their achievements in their sciences as the 'cleverest among the dark people'. Baghdad's book seller Ibn al-Nadim, al-Biruni, al-Ashari, Shahrastani and many other writers devoted chapters in their books to Indian religions and sciences. Al-Nubakhti's *Kitab al-ara-I wal adnya-i-Madhahib al-Hind* mentioned by Masudi was perhaps the earliest study of Hindu sects. Sulayman the merchant visited India about 851 and praised Hindi proficiency in medicine, astronomy and philosophy. Contact with Hindu sciences came to an end when the political grip of Baghdad on Sind was loosened.

During the Mughal rule of India, science & technology developed mainly due to the interests of Emperors and Sultans, particularly in astronomy, agriculture, engineering, architecture and medicine. A number of encyclopaedias and dictionaries were penned. Initially dictionaries were needed as new ideas were being developed as a result of interaction between Sanskrit and other languages. During the later period of Mughal rule, new ideas were accepted from European science and technology.

In sciences the Hindus had developed elaborate systems in mathematics, astronomy and medicine; the Muslims were obliged to Hindus and Greeks for these departments of knowledge. In due time Muslims built up original structures of their own scientific systems. When Muslims arrived in India they brought their own knowledge which was not inferior to Hindus. The Hindus did not disdain to incorporate what they found new. Thus the Hindus astronomers took from the Muslims a number of technical terms, the Muslim calculation of longitudes and latitudes, and various other items of calendar, Zij. (3)

**Al-Biruni**

Abu Rehan al-Biruni (d.1053) was the first scientist of Islam who made a deep study of Hindu sciences. He was the first scholar to study India and the Hindu scientific literature. He has been described as the founder of Indology. He studied Sanskrit diligently and was so proficient in it that he could translate into, as well as from Sanskrit.
Hindu scholars gave him the title of Vidya-sagar (ocean of knowledge).

Until the 10th century, history most often meant political and military history, but this was not so with him. In his *Kitab fi Tahqiq ma li'l-Hind* (*Researches on India*), he described India's cultural, scientific, social and religious history. Due to military incursions of King Mahmud of Ghazna in India, Hindu scholars had moved to remote religious centres. In this charged atmosphere Biruni imposed upon himself the strict discipline of scientific objectivity. He tried to explain Hindu doctrines without any bias, avoiding any kind of polemics.

Biruni's approach to Hindu sciences was comparative, making analogies between Greek and Hindu civilizations. His comparison of two civilizations led him to the conclusion that Hindus could not bring sciences to classical perfection, and that scientific theories of the Hindus "*are in a state of utter confusion, devoid of any logical order, and in the last instance always mixed up with the silly notions of the crowd".* (Kitab al-Hind)

Biruni regarded the essence of Hindu religion as a form of monotheism, idol worship as ignorant passions of the people. He was the first to introduce the study of *Bhagavad Gita* to the Muslim world, and the first Muslim to study the *Purana*s and to translate *Patanjali* and *Samkhya* into Arabic. In considerable detail he outlined the principles of Hindu astronomy, geography, mathematics and medicine. (4)

Biruni translated a Sanskrit book *Batakal*, as Bátanjal. From this work he extracted a great deal which he made use of in his magnum opus Q*ánún Mas'údi*, a 1500 page work on mathematics, geometry and astronomy. All that the sages of India have said about numbers, ages, and eras (*tawáríkh*), has been exactly given by Abú Rehan in his translation of the Bátakal. (5)

**Sultans of Delhi**

Jalal al-Din Khilji (d.1296) is the first Muslim sultan of Delhi to have showed some intellectual curiosity for Hindu learning and Sanskrit studies. Sultan Muhammad bin Tughlaq (1351) was a great scholar versed in logic, Greek philosophy, mathematics, astronomy and physical sciences. He had knowledge of medicine and was skillful in dialectics. He also was an expert calligrapher. He enjoyed the society of Hindu yogis and extended his patronage to Jain divines. Zia al-Din Nakhsabi's adaptation of 52 short stories from Sanskrit into Persian in 1330 entitled *Tuti Nama* (Book of Parrot) is the outstanding achievement of Tughlaq's reign in this field.

The Sultans of Delhi were very much interested in mechanical machines like pulleys and piers. In the book *Sirat Feroz Shahi* (1370) 13 such instruments were listed which were used in transporting stones and heavy building materials. A manuscript of *Sirat* is preserved at Bankipur library. During the rule of Sultan Nasir Shah (1500-11) a scholar by the name of Muhammad ibn Daud translated many Arabic books into Persian which was then the official language of the state.

Sultan Firoz Shah Tughlaq (1388) allowed more than a third of a million pounds (36 lacs) to learned men and pious endowments. (6) A number of Madrassas were opened to encourage literacy. He set up hospitals for free treatment of the poor and encouraged physicians in the development of Unani medicine. He commissioned translations of medical works from Sanskrit. He ordered a work on Hindu astronomy and astrology to be translated into Persian under the name of *Dalaile Firoz Shahi*. Works on music and wrestling were also translated. Ziya al-Din Barani (1357), wrote a chronological history of Tughlaq's rule, entitled *Tarikh-i-Firoz Shahi*. Genuine interest and patronage of Sanskrit learning began with Sultan Zain al-Abidin of Kashmir (1420-1470) who commissioned the translations of *Mahabharta* and *Raja-tarangini* into Kashmiri language, which was first indication of Muslim interest in the pre-Muslim Hindu history of India.

**Intellectual curiosity of Emperor Akbar**

The Mughal Emperors (1526-1858) took a keen interest in the development of astronomy. They patronized astronomers in their royal courts. The works thus produced were mainly *zije*s (astronomical tables) and calendars. Many scientific works brought from outside of India like Bahauddin Amuli's (1574-1621) *Khulasa tul-Hasab*, and Tusi's *Tahrir Uqlidis* and *Tahrir al-Majisti*. Attempts were made to write commentaries and translate these works. As a result the intermingling of Indian mathematical tradition with Arabic & Persian did take place enriching the country.

Emperor Humayun (1556) built a personal observatory near Delhi, while Jahangir and Shah Jahan were also intending to build observatories but were unable to do so. Mulla Chand, a court astronomer of Emperor Nasiruddin Humayun produced "*Tashil Mulla Chand*", which was a redaction of *Zije Ulugh Beg*.

Muslim patronage of Hindu learning reached its highest watermark in the court of Emperor Jalal al-Din Akbar (d.1605). Some of the Hindu nobles in his court wrote in Persian and Sanskrit, like Raja Manohardas and Raja Todar Mal (d.1589) who translated *Bhagavata Purana* into Persian. Akbar had a stupendous library composed entirely of manuscripts written and engraved by skilful penmen. The volumes in his library numbered only 24,000 but they valued at $3,500,000. A translation bureau called *Maktab Khana* was established in the Diwan Khana of Fatehpur Sikri. He patronized poets and learned men. He supervised the translation of *Mahabharta* into Persian. (7). In 1578 he ordered Abul Fazl to translate the *New Testament into Persian*. No copy of this translation is extant, but it appears he made the translation with the help of the Catholic Fathers. (8) The translation of Ramayana was undertaken by Abdul Qadir Badauni on the express command of Akbar in 1585 and completed in 1590. The *Harivamsa Purana*, supplement to *Mahabharta,* was translated by eminent Persian poet Mulla Sheri.

Some Muslim nobles like Abdul Rahim Khani-i- Khana, Abul Fazl and Faizi knew some Sanskrit and translated from it. In 1584 Akbar ordered Mulla Abdul Qadir Badauni to translate from Sanskrit into Persian *Singhasan Battisi*, embodying the stories of Bikarmajit and the 32 statutes. A learned Brahmin was appointed to be Badauni's collaborator to interpret Sanskrit text for him. The Persian work was entitled *Nama-i- Khirad* (The Wisdom Augmenting Book). Next year Akbar ordered Abul Fazl to translate from Arabic into Persian *Hayatul Haiwan*, the celebrated zoological dictionary, compendium of folklore, and popular medicine, authored by Musa al-Damiri (d1406).

In the preface to his Persian translation of *Mahabharata,* Abul Fazl says: "Akbar initiated a policy so that in his age the pillars of blind following were demolished and a new era of research and enquiry in religions matters commenced". (9) Faizi paraphrased the first two *puranas* into Persian verse. Taj al-Ma'ali translated a Sanskrit work and called *Mufarrih al-Qulub,* manuscript is at Indian Office library, MS 3350. (10)

Father Monserrate presented to Akbar an *Atlas* sent to him by Archbishop of Goa. He had written in his travelogue that he had seen Akbar working on machines and giving instructions on how to make new machines. This is how he described Emperor Akbar:

"*He is a great patron of learning, and always keeps around him erudite men, who are directed to discuss before him philosophy, theology, and religion, and to recount to him the history of great kings and glorious deeds of the past. He has an excellent judgment and a good memory, and has attained to a considerable knowledge of many subjects by means of constant and patient listening to such discussions. Thus he not only makes up for his ignorance of letters (for he is entirely unable either to read or write), but he has also become able clearly and lucidly to expound difficult matters. He can give his opinion on any question so shrewdly and keenly, that no one who did not know that he is illiterate would suppose him to be anything but very learned and erudite." The Commentary of Father Monserrate, on his Journey to the Court of Akbar 1591.* http://www.columbia.edu/itc/mealac/pritchett/00generallinks/txt_monserrate_akbar.html#letters

Shaikh Abu al-Faiz ibn Mubarak – pen name Faizi (1547-95) was a poet laureate of Emperor Akbar. At the suggestion of Akbar, Faizi translated Bhaskar Acarya's (1114-60) Sanskrit work on mathematics *Lilavati* into Persian in 1587; it contained theorems of arithmetic and algebra. The translation was so popular that Ataullah Rashdi Lahori translated Bhaskar Acarya other books on algebra and measurement. Faizi, a prodigious author of 100 books, translated few mathematical problems from Latin into Persian also.

The famous book covering the administration of Emperor Akbar, A'*eenay Akb*ari written by Abul Fazl Allami ibn Mubarak (d.1602), described West and Central Asian astronomy. Abū al-Fażl's greatest literary accomplishment was the monumental *Akbar-nāmah* in 3 volumes. Among his many works is a Persian translation of the Bible. Authors of later generations admired his style and sought to imitate it. *Zije Ulugh Beg,* prepared by Sultan Ulugh Beg (1393-1449) in Samarkand was translated into Sanskrit, entitled *Ulakabegijica*.

**Astronomy**

The Persian-Indo polymath, Fatehullah Sherazi (d.1582), a scientist at the court of Emperor Akbar (d.1605) reformed the Calendar. He translated three Sanskrit astronomy work into Persian. One of his inventions, a military weapon, was designed for killing infantry, an early volley gun with multiple gun barrels similar to hand cannons. Another cannon-related machine he invented which could clean sixteen gun barrels simultaneously, and was operated by a cow. He also developed 17 barrelled cannon, fired with a matchlock.

Emperor Noor al-Din Salim Jahangir (d.1627) continued the patronage of translations from Sanskrit into Persian as well as of Hindu scholars who wrote on Hindu law, sciences and lexicography. Jahangir was an excellent writer and loved nature. He recorded various details of flora and fauna from all over India. He was not only curious, but a scientific observer of minute details of species. A number of his observations are detailed in his autobiography *Tuzk-e-Jahangiri. http://persian.packhum.org/persian/main?url=pf%3Ffile%3D11001080%26ct%3D0*

Fariduddin Munajjum, a court astronomer of Shah Jahan (d.1666), compiled *Zije Shah Jehani.* The first section of the tables dealt with various calendars, second section dealt with spherical astronomy, third section dealt with determination of the motions of the planets and their positions in the sky. The Zij was translated into Sanskrit under the title *Siddhanta-Sindhu*, by Nityananda at the command of vizier Asaf Khan & completed in 1635. A copy of the manuscript at Jaipur Museum once belonged to Emperor Shah Jahan, his seal is on folio 1. The Sanskrit translations consisted of 440 pages, 11 copies of this written on 'jahazi' paper, 45x33 cm were distributed among the aristocrats of North India. Four copies are at Jaipur palace library. Nityananda explained the Arabic and Persian technical terms for the benefit of Hindu astronomers while giving differences between Islamic and Hindu astronomy. He devised new technical terms during the translations, which were later used in the translations Phillipe de Hire's Latin tables into Sanskrit.

Malajeet was an astronomer at Shah Jahan's court. He wrote *Parsiprakasa* (1643) which gave Arabic, Persian astronomical terms and their Sanskrit equivalents. Two Hindu scholars namely Nitya Naad, & Menisvara, used Arabic, Persian and Greek works to synthesize Islamic traditions with those of India. Mulla Mahmud Jaunpuri was a versatile scholar, expert in mathematics and astronomy. His book *Shamsay Bazegha* and *Shamsey Baligha* bring out outstanding features of astronomy. Emperor Shah Jehan wanted to construct an observatory for Mulla Jaunpuri, but could not do so on account of financial constraints on the royal treasury. Abdur Rahman Chisti (1683) explained the Hindu theories of cosmogony in his *Mira't Makhluqat*.

**Maharajah Sawai Jai Singh**

Maharajah Sawai Jai Singh (d.1743) was an astronomer of the first order & the most enlightened king of 18th Century India. He had some Greek works on mathematics (including *Euclid*) translated into Sanskrit as well as more recent European works on trigonometry, logarithms and Arabic texts on astronomy. As he found the prevalent tables in use at the time defective, he decided to prepare new ones. First he built metal instruments which, however, did not come up to his idea of accuracy. Therefore he constructed at Delhi huge masonry instruments. Subsequently, to verify the correctness of his observations, he constructed instruments of the same type in Jaipur, Mathura, Banaras and Ujjain observatories. In his five observatories Hindu and Muslim observers were employed and produced a set of astronomical tables called *Zijey Jadid Muhammad Shahee*. He was fluent in Persian and Arabic and was acquainted with *Zij-i-Ulugh Be*g. He incorporated in his works latest European astronomical knowledge as is evidenced from the Zij which was based on Latin tables of Phillipe de Hire (d.1718). *Zije-i-Jadid* first section deals with calendars, the second deals with determination of heavenly bodies and third covers the motions of the Sun, Moon and the rest of the planets, eclipses of the Sun & Moon, the appearance of the new Moon.


the author of this article visited this observatory Jantar Mantar in Delhi in March 2009.

There is evidence that Rajah used a telescope for his observations of the celestial bodies. This telescope was brought by Father Bandier who had visited Jaipur. His observations of Venus and Mercury, the rings of Saturn and Sunspots are proof that he employed a telescope. The 16th and 17th centuries saw a synthesis between Islamic astronomy and Indian astronomy, where Islamic observational techniques and instruments were combined with Hindu computational techniques. While there appears to have been little concern for theoretical astronomy, Muslim and Hindu astronomers in India continued to make advances in observational astronomy and produced nearly 100 Zij treatises.

Jai Singh's brahman tutor Samrat Jagannath, translated Allama Nasiruddin Tusi's *Tahrir al-Majisti* into Sanskrit entitled *Samrat Siddhanta* in 1732. He also translated Tusi's *Kitab Usul al-Hindasa* which was based on Euclid's *Elements.* Nayansuk-hopadhaya translated Tusi's *Tahrir al-Ukar* into Sanskrit entitled *Ukara*. A manuscript is preserved at Jaipur Museum library. *Yantra-prakara* was composed for Raja Jayasimha in Dehli in 1729 based on *Tahrir al-Majisti,* later translated into Sanskrit by Jagannath.

Descriptions of 275 astronomical manuscripts still housed in the palace library of Jaipur help clarify how Raja Jayasimha was led to rely on observations for practical astronomy and on European theories for accurate calculations of celestial phenomena.

*Sarahtjagkira Virjandi* is a translation into Sanskrit of Chapter 11 of Book 2 of Tusi's *Tadhkira* with Birjandi's sharah completed by Nayanasukho-padhya assisted by Muhammad Abidda, completed in December 16,

1729. It is evident that Persian polymath Nasiruddin Tusi (1201-1274) and mathematician Bahauddin Amuli (1547-1621) books were very popular in India.

Following is a list of Arabic/Persian astronomical tables at Jaipur which were translated into Sanskrit in India.

1. Bist dar bab Usturlab by Tusi
2. Kitab al Ukarr, translation from Greek by Qusta ibn Luqa, 9th century
3. Risala dar Hai'ya
4. Risala dar Usutrlab
5. Sharah al-Tadhkira by Tusi (Resume on astronomy)
6. Tahrir al-Majisti by Tusi (Redaction of al-Majisti)
7. Tahrir Hisab usul al-Hindasa
8. Tahrir al-Ukarr by Tusi
9. Zij I Jadid by Ulugh Beg completed in 1437.
10. Zij-e- Khaqani by Jamshed al-Kashi
11. Zij-e-Shah Jahani

Ghulam Hussain Jaunpuri was the author of *Zijey Bahadur Kha*ni (1846) which was based on the observations made by the author himself. It also covered mathematics, trigonometry, optics and astronomy.

## Technology

Fathullah Shirazi (c. 1582), was a Persian-Indian polymath and mechanical engineer who worked for Akbar. He developed a Volley gun. Considered one of the most remarkable feats in metallurgy, the seamless globe was invented in Kashmir by Ali Kashmiri ibn Luqman in 1589-90, and twenty other such globes were later produced in Lahore and Kashmir during the Mughal Empire. Before they were rediscovered in the 1980s, it was believed by modern metallurgists to be technically impossible to produce metal globes without any seams, even with modern technology. Another famous series of seamless celestial globes was produced using a lost-wax casting method in the Mughal Empire in 1659-1960 by Muhammad Salih Tahtawi (from Thatta, Sind) with Arabic and Persian inscriptions. It is considered a major feat in metallurgy. These Mughal metallurgists pioneered the method of wax casting while producing these seamless globes.

## Instruments

Astrolabe used for astronomical observations was developed and improved upon in India. Humayun patronized astrolabe manufacturing. The astrolabe maker at his court was Allahdab Asturlabi Lahori whose sons and grandsons also made astrolabes. Lahore seemed to have been a major centre for the manufacture of astronomical instruments. Maharajh Jai Singh constructed a number of astrolabes which were made from masonry, i.e. Smarat Yantra, Jai Prakash, Ram Yantra, Misra Yantra.

Few years ago, I visited the Adler Astronomy Museum in Chicago, located near the banks of Lake Michigan. There were 31 astrolabes on display in the Islamic astronomy section. There was a map of the Islamic world on the wall, and a list of eminent Muslim astronomers, of whom Nasir al-din Tusi was on the top of the list. One could do experiments, like finding Mecca using an astrolabe, or using an alidade on the astrolabe one can determine the degree at which a certain star is located in the sky. I saw one astrolabe which had the following inscription on it: Amal Ziauddin Muhammad ibn Mulla Humayun asturlabi Lahori 1057 AH. (i.e. 1647 ad)

The instruments and observational techniques used at the Mughal observatories were mainly derived from the Islamic tradition, and the computational techniques from the Hindu tradition. In particular, one of the most remarkable astronomical instruments invented in Mughal India is the seamless celestial globe.

Spanish astronomer & instrument maker Ibrahim Al-Zarqali's (1087) treatise on the universal astrolabe *Safiha* was translated into Sanskrit as *Jarakali-Yantra* by Nayansuk-hophadhaya and was incorporated into Jagan Nath's *Siddhanta Kaustubya* around 1730.

**Mathematics**

Most of the available Sanskrit literature was translated during the Muslim rule of India, and in some instances Muslims made significant contributions. Euclid's *Elements* was translated into Arabic by Allama Nasiruddin Tusi, while Qutub al-Din Sherazi had translated it in 1311into Persian. Based on these translations, Abdul Hamid Muharrar Ghaznavi wrote *Dastur al-Bab fee Ilm al-Hisab* after 26 years of intensive labor.

One of the distinguished families of Punjab that made significant contributions to mathematics was Ustad Ahmad Lahori, aka Ahmad al-Mima'r, (1580-1649) the architect of Taj Mahal & Red Fort. One of his sons Ataullah Rashedi translated Bij Ganita describing the reign of Emperor Shah Jehan. (reigned 1628–58) He also wrote *Khulasa Raaz* in Persian which dealt with arithmetic, algebra, and measurement. His other book *Khazinatul A'adad d*ealt with arithmetic, geometry of Euclid and algebra. Another son Lutfullah Muhandis wrote *Risala Khaws A'adad* dealing with properties of numbers. He was also author of *Sharah Khulasa al-Hisab* and his *Muntakheba*t was a translation of Persian mathematician Bahauddin Aamili's *Khulasa tul--Hisab* (epitome of mathematics).

Imad al-Din Riyadi, the grandson of Ustad Ahmad was also a versatile scientist. He wrote a commentary on Amuli's *Khulasa tul-Hisab*, entitled *Hashiya bar Sharah Khulasa* which consisted of a preface, ten chapters and an appendix. Besides these he wrote a commentary on *Sharah Chaghmani* entitled *Hashiya bar Sharah Chaghmani*. He also wrote a book on problems of spherical astronomy and geometry. On music he authored *Risala Dar Ilm Museekee* which covered a wide range of topics on philosophy.

It appears that mathematics was not only associated with accountancy and revenue collection, but with astronomy and architecture as well. A number of translations were made from Persian & Arabic into Sanskrit. Maharajh Sawai Singh made major contributions in trigonometry, which was to find the sine of one degree and its parts, namely minutes and seconds.

Abul Khair Khairullah, grandson of Ustad Ahmad Lahori, wrote a commentary on *Zij Muhammad Shahi,* translated *Almagest* as well as wrote a commentary on it. He was appointed director of the Dehli observatory in 1718. His other major works were: *Majmu'a al-Madkhil fil al-Najoom* & *Majmu'a al-Saboot al-Qudsia*.

*Khazinatul Ilm* (Treasury of Knowledge) was a Persian book by Khawaja Azimabadi dealing with arithmetic, geometry, astronomy along with English terminology and their translations into Persian. This is also reflected in the works of Fakhruddin Khan Bahadur, author of *Risala dar Biyan Amal al-Qata* and *Shamsul Hindsa*, which are on measurement, geometry and trigonometry.

**Medicine**

Muslim practitioners were known by their designation Hakim or Tabib. Hakim means a scientist or a learned man while Tabib means a physician. The Jarah was a surgeon, surgery was called Ilmey Jarahat. Most of the medical & scientific books were written in Arabic and Persian**.**

Islamic medicine in India was founded on books of two Persian physicians, namely Zakariya Razi and Hakim ibn Sena. During the rule of Tegin (1098-1127) a scholar from Khawrazm Hakim Zainuddin Ibrahim Ismail wrote a book on medicine called *Zakhirah Khawazim*. This compendium asserted great influence in India from 12$^{th}$ to the 15$^{th}$ century. The book described definition of medicine, diagnosis of an illness, reasons for illness, fevers, types of poisons and constitution of human body. He also wrote another book *Aghraz al-Tibb* which was also very popular among the local practitioners of medicine. His *Tibbey Yadgar* was an extensive pharmacopeia in 14 chapters. Physician Nafees Ibn Kirmani (d.1424) wrote a book entitled *Tibbey Akbari*.

Hakim Mansur ibn Ahmad was a Persian who had settled in Kashmir. He authored a book *Kafaya al-Mujahideen*, on the diseases of women and children and their treatment. This was dedicated to Sikandar Shah II of Dehli. One of the secretaries of Emperor Humayun Yusuf ibn Muhammad Herati wrote a book on various diseases and their remedies. Muhammad Momin wrote *Tuhfatul Mominin* which was a compilation of various Arabic & Sanskrit authorities, on the whole field of medicine. *Madan al-Shifa Sikandar Shahi* was written in 1512 by Beva-bin-Khas., a vizier of Sultan Sikandar Lodhi, synthesizing Islamic and Sanskrit medicine. Famous historian Hindu Shah wrote *Dastul al-Ittiba'a.* Hakim Nooruddin Abdulla was a nephew of abul-Fazl, vizier of Akbar. He wrote a book *Alfaz al-Adwiyy*a on material medica giving names in Hindi, Arabic, Persian, Latin, Spanish, Turkish and Sanskrit. The book was dedicated to Emperor Shah Jahan.

Hakim Ali Gilani (1554-1609) was not only a physician but a renowned mathematician and a scientist. He was attached to the court of Akbar who had given him the title of *Jalinoos al-Zaman* (Galen of the world). He was the only Indian physician to have written a commentary of all five volumes of *al-Qanun*. The first volume of the commentary *Jamay al-Sharahein* was published from Lucknow in 1850. Another book of his on medicine is called *Mujarrabatey Gilan*i (tested remedies). Emperor Jahangir believed that Akbar was poisoned by Hakim Gilani.

Muhammad Raza of Shiraz wrote a treatise *Riaz-i- Alamgiri* on medicine, food and clothing, and was dedicated to Aurangzeb. Muhammad Akbar Arzani, court physician of Aurangzeb, wrote *Tibb-i-Akbari* in 1678, which was in fact translation of Sharh -ul-Asbab. Arzani also wrote *Tajriba-i-Akbari*, based on author's own experiences.
His Qarabadain Qadri was an extensive pharmacopeia of medicine extensively used in India. Imam Ghulam Hakim wrote in Persian *Elaj al-Ghura*ba (treatment of special diseases) which was reprinted several times during the 19th century due to its immense usefulness.

Hakim 'Alavi Khan was born in Shiraz, in Persia, in 1670. In 1699 he went to India and presented himself at the Mughal court of Afghans, where he was appointed physician to Prince Muhammad A'zam (who was later to rule for only three months in 1707). The Mughal ruler Bahadur Shah (ruled. 1707-12) gave him the title 'Alavi Khan. Muhammad Shah (reg.1719-1748), the Mughal ruler in Delhi, raised him to the rank of *Shash-hazari* and gave him the title of *Mu'tamad al-Muluk*. When the Persian ruler Nadir Shah defeated Muhammad Shah and sacked Delhi, 'Alavi Khan accompanied Nadir Shah when he left India and 'Alavi Khan accepted the position of *Hakim-bashi* ("chief physician") to Nadir Shah. After making a pilgrimage to Mecca, 'Alavi Khan returned to Delhi in 1743 and died there about four years later. He wrote four medical treatises in Arabic and four in Persian. His nephew Muhammad Husayn ibn Muhammad Hadi al-'Aqili al-'Alavi al-Khurasani al-Shirazi (fl. 1771-81), known as *Hakim Muhammad Hadikhan*, used 'Alavi Khan's pharmacopoeia titled *Jami' al-javami'-i Muhammad-Shahi*, which was dedicated to the Mughal ruler Muhammad Shah. A large portion of this comprehensive work written in 1771 is on simple and compound remedies.

*Sihatul Amraz* by Pir Muhammad Gujrati 1726 contained prescriptions for cure of all diseases.

Following is a list of *undated* medical manuscripts preserved in India.

1. *Khulasat –ut-Ti*bb: by Muhammad bin Masood, a short treatise on medicine, on the art of dying, and paper making.
2. *Asrar-i-Ittiba*: by Shihab al-Din, essays on the virtues of amulets, medicine, charm for averting disease.
3. *Shifa ar-Rijal:* Shihab al-Din, poetical treatise on medicine
4. *Bahr-ul-Manafia*: 1794 by Maulood Muhammad, dedicated to Tipu Sultan, treatise on midwifery, children, exorcising devils, enchantments etc.
5. *Qanun-dar-Ilm-Tibb*: a translation by order of Tipu Sultan, a complete pharmacopeia.
6. *Tarjuma Kitab-i-Farang*: a translation of Dr Cookburn's treatise on twist of the intestines.
7. *Mufradat dar-Ilm-Tibb*: on botany and natural history, translated by order Tipu Sultan from French & English.
8. *Risala Tib-i-Aspan*: translation from Sanskrit by Zain al-Din 1519 and dedicated to Shamsuddin Muzafar Shah on farriery.
9. *Kitab al-Sumum*: by Shanka of India, translated into Persian by Hatim, later by Abbas Saeed Jauhari.
10. *Sharah Hadae-tul-Hikma*: by Muhammad bin Ibrahim, qazi of Shiraz, contains the whole course on sciences read in schools. It was much esteemed by Muslims of India.

11. *Makhzanul Adwiyya*: by Hakim Muhammad Hussin, printed in Persian.
12. *Tazkira-tul-Hind*: by Hakim Razi Ali Khan, on materia medica in Persian, written in early part of 19th century, lighographed in 1866 Hyderbabad.

In the 17th and 18th century when Persian medicine almost died in Iran, it was kept alive in India. Cyril Elgood observes, " When Persian medicine almost died of inanition in Persia, it was kept alive by the Hakims of Delhi & Lucknow. Its literature was preserved by the printing presses of northern India. It was to them that we owe the first printed editions of such famous works as *Tashrih-i-Mansuri, Tuhfatul Momineen*, and *Tuhfatul Ashiqeen* of Avicenna." (11)

## Pharmacy

Sultan Alauddin Khilji (1296-1316) had several eminent Hakims in his royal courts. This royal patronage was a major factor in the development of Unani practice in India, but also of Greco-Islamic (Unani) medical literature with the aid of Indian Ayur-vedic physicians.

During the reign of Moghul kings of India several Qarabadains were compiled like Qarabadain Shifae'ee, Qarabadain Zakai, Qarabadain Qadri and Elaj-ul-Amraz. In these pharmacopoeias quantities of drugs in a given prescription were specified, and methods of preparation. The court physicians supervised the preparations of royal medicine, which were sealed to ensure safety. Hakeem Ali Gilani was the chief physician of Emperor Akbar and used to accompany him in his travels. Hakim Gilani used to carry his pharmacy with him in these travels. He invented a kind of sweet wine for getting rid of traveling fatigue. During the reign of Emperor Jehangir, Itr-i-Jehangiri was discovered by Queen Noor Jehan. Hakim Ain-ul-Mulk Shirazi composed for his royal patron emperor Shah Jahan *Alfaz-al-Adwiyya* (vocabulary of drugs). It was printed in 1793 in Calcutta, and rendered into English by Gladwin. Hakim Akbar Arzani, was a court physician of Emperor Aurangzeb. He wrote *Tibbe Akbari*, and *Mizan al-Tibb*.

During the British rule, Eastern medicine in India declined. However the famous house of Hakim Sharif Khan of Delhi made a concerted effort to rejuvenate the decaying art of Unani medicine. Hakim Ajmal Khan founded the Hindustani Dawakhana and the Tibbiya College in Dehli. At the Tibbiya College, Dr Salimu-Zaman Siddiqui carried on chemical investigation of certain potent drugs and *Ajmailain* was produced. At Lucknow, the Talim al-Tibb college was established under the auspices of Hakim Abdul Aziz.

Hakim Kabir al-Din **was** a distinguished author who wrote four books on Eastern system of medicine: *Masaela Dauran-ey-Khoon, Sharah Qanoon Shaikh, Tashrih Kabir, Ilm al-Adwiyya and Burhan.*

Muhammad Husayn al-Aqili al-Alavi, a practitioner and grandson of a well-known Indian practitioner wrote in 1732 *Makhzan al-adwiyah dar-i bayan-i adwiya(* ***The Storehouse of Medicaments Concerning the Explanation of Materia Medica).*** The illuminated Persian manuscript, now at the National Library of Medicine, USA is in alphabetical order. http://www.nlm.nih.gov/exhibition/islamic_medical/islamic_11.html

At Lahore Hakim Ghulam Nabi and Hakim Ghulam Jeelani promoted Eastern medicine by writing books such as: Tarikh al-Ittiba, and Makhzan al-Adwiyya. After the demise of Hakim Ajmal Khan, Hakim Abdul Majid (d.1922) started a pharmacy in 1906 which blossomed into Hamdard Waqf Laboratories. Hamdard now is a leading pharmaceutical house in India and Pakistan.

## Chemical Technology

Chemical technology during the Muslim rule was centred on five areas:
1. Preparation of drugs 2.preparation of perfumes and cosmetics 3.preparation of beverages including fermented ones 4.making of dyes 5.making gun-powder, and pyrotechnics.

Rockets were also made with gunpowder in them. Some rockets went in the air and some went along the surface. Tipu Sultan (d.1799) and his father Hyder Ali (d.1782) are regarded as pioneers in the use of solid fuel rocket technology or missiles for military use. A military tactic they developed was the use of mass attacks with rocket brigades on infantry formations. Tipu Sultan wrote a military manual called *Fathul Mujahidin* in which 200 rocket men were assigned to each Mysore a "cushoon" (brigade). Mysore had 16 to 24 cushoons of infantry. The areas of town where rockets and fireworks were manufactured were known as Taramandal Pet ("Galaxy Market"). It was only after Tipu's death that the technology eventually reached Europe.

The rocket men were trained to launch their rockets at an angle calculated from the diameter of the cylinder and the distance to the target. In addition, wheeled rocket launchers capable of launching five to ten rockets almost simultaneously were used in war. Rockets could be of various sizes, but usually consisted of a tube of soft hammered iron about 8 inches (20 cm) long and 1.5 to 3 in (3.8 to 7.6 cm) in diameter, closed at one end and strapped to a shaft of bamboo about 4 ft (1 m) long. The iron tube acted as a combustion chamber and contained well packed black powder propellant. A rocket carrying about one pound of powder could travel almost 1,000 yards. In contrast, rockets in Europe, not being iron cased, could not take large chamber pressures and as a consequence, were not capable of reaching distances anywhere near as great.[57]

Hyder Ali's father, the Naik or chief constable at Budikote, commanded 50 rocket men for the Nawab of Arcot. There was a regular Rocket Corps in the Mysore Army, beginning with about 1200 men in Hyder Ali's time. At the Battle of Pollilur (1780), during the Second Anglo-Mysore War, Colonel William Baillie's ammunition stores are thought to have been detonated by a hit from one of Hyder Ali's rockets, contributing to a humiliating British defeat.

After the fall of Srirangapattana, 600 launchers, 700 serviceable rockets and 9,000 empty rockets were found. Some of the rockets had pierced cylinders, to allow them to act like incendiaries, while some had iron points or steel blades bound to the bamboo. By attaching these blades to rockets they became very unstable towards the end of their flight causing the blades to spin around like flying scythes, cutting down all in their path.

These experiences eventually led the Royal Woolwich Arsenal to start a military rocket research and development program in 1801, based on the Mysorean technology. Their first demonstration of solid-fuel rockets came in 1805 and was followed by publication of *A Concise Account of the Origin and Progress of the Rocket System* in 1807 by William Congreve. http://en.wikipedia.org/wiki/Tipu_sultan.

## Metallurgy

Various types of weapons were made in India. Zinc was not known in Europe, but extracted in India. Many alloys were made, iron, steel, brass, bronze used in making weapons. These kinds of weapons were produced in a plant called *Karkhana*. Descriptions of castings of cannons are found in *Babur Nama*.

**Screw cannon**: in order to carry heavy cannons on hill tops the cannon was made in pieces and assembled subsequently. Multi-barreled cannons were made in order to fire 17 barrels successively. For coating the surface of copper with a mixture of zinc and tin, threads were made from various metals like gold, silver which were used in textile. Gold & silver leaf was produced for use in goods and medicines. Another dimension of metallurgy was production of gold, silver and copper coins.

## Conclusion

During the Muslim rule of India considerable work was done in mathematics, medicine, astrology, astronomy, and translations of various texts. Custodians of faith filled the minds of people with superficial things and did not allow enquiry into religious dogmas. Science was not patronized as a state policy by Kings or the Raja’s. It is unfortunate science and technology was not pursued rigorously as it was being developed in Europe. No scientific institutions were set up, nor were students sent to Europe for higher studies. The money that was spent on constructing monumental edifices, had it been spent on creating scientific institutions, India could have become an advanced country long time ago.

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**Refrences:**

**1.**. A Hist of Astronomy from Thales to Kepler, by J.L.E. Dreyer, NY, 1953, p 244
2. Aziz Ahmad, Islamic Culture in the Indian Environment, Oxford, 1964, p 109
3. Tara Chanda, Influence of Islam on Indian Culture, Lahore, 1979, p140
4. Aziz Ahmad, Islamic Culture in the Indian Environment, Oxford, 1964, p 113
5. Sir H.M. Elliot, The History of India, as Told by Its Own Historians. The Muhammadan Period, UK 1877
6. S. Lane-Poole, Medieval India, 712-1764, 1963, Dehli, p112
7. W. Durant, The Oriental Heritage, NY 1954, p 461
8. S.A.A. Rizvi, Religious & Intellectual History of Muslims, Dehli, 1975, p 206
9. S.A.A. Rizvi, Religious & Intellectual History of Muslims, Dehli, 1975, p 209
10. Aziz Ahmad, Islamic Culture in the Indian Environment, Oxford, 1964, p 220
11. C. Elgood, Medicine in Persia, NY 1934, page 68

Bibliography

-Edward Balfour, Cyclopaedia of India & of Eastern & South Asia, Vol 2.
-Mohammad Taher, Educational developments in the Muslim World, Dehli, 1997
-Mona Baker, Routhledge Encyclopaedia of translation studies, UK, 1998
-Father Monserrate, His journey to the court of Akbar, London, 1922
-A. Rogers, Tūzuk-i-Jahangīrī Or Memoirs Of Jahāngīr, London 1914
-Tara Chanda, Influence of Islam on Indian Culture, Lahore, 1979, p140
- C. Elgood, Medicine in India, NY 1934
- S.B. Ashri, Delhi's Jantar Mantar Observatory, New Delhi, 2005
- Andreas Volwahsen. Cosmic Architecture of India, Astronomical Monuments of Jai Singh, London, 2001
- V.S. Bhatnagar, Life and times of Sawai Jai Singh, Delhi, 1974
- Zakaria Virk, Biography of al-Biruni, Nia-Zamana, Lahore 2007
- A.Y. al-Hasan, Science & Technology in Islam, UNESCO 2001

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Chapter 12

# Muslim Contribution to European Awakening

Muslim presence on the European continent has a long history. A brief look into the past reveals that Muslims conquered Spain merely eighty years after the death of Prophet of Islam. They ruled Spain for nearly seven hundred years, whereas in 732 they almost captured Paris. Sicily was conquered in 831 and Islamic rule lasted there for three hundred years. In 841 Muslim fighters took Bari, the main Byzantine military base in Italy. In 846 eleven hundred Muslim *ghazis* marched up to the walls of Rome. In 849 they made another attack on Rome to seize the citadel of Christianity. In 876 Rome was endangered to such an extent that Pope John VIII agreed to pay a tribute of 25,000 *mancusi* (dollars). Had Rome fallen, the entire European continent would have been obliged to recite the Kalima. Muslims captured Malta in 869 AD, and from their conquered territories in Italy & Spain they raided Alpine passages into Europe. It was mainly through Spain and Sicily that light of knowledge spread to Europe. Christian students from France, England, Germany, and Italy flocked to Universities of Cordoba & Granada to be tutored by Muslim scholars and scientists.

Scholars agree that science and philosophy would not have developed to this degree without significant Muslim contributions. This is attested by Professor Watt in one of his scholarly work in these words " *When one becomes aware of the full extent of Arab experimenting, Arab thinking and Arab writing, one sees that without the*

*Arabs European science and philosophy would not have developed when they did. The Arabs were no mere transmitters of Greek thought, but genuine bearers, who both kept alive the disciplines they had been taught and extended their range. When about 1100 Europeans became seriously interested in the science and philosophy of their Saracen enemies, these disciplines were at their zenith; and the Europeans had to learn all they could from the Arabs before they themselves could make further advances.* " (1)

While Europe was going through its age of darkness, Islamic Spain was in the vanguard of technical progress and material prosperity. Cordoba was the most civilized city on the European continent. It's prosperity and intellectual achievements were paralleled to fabulous Baghdad. It had awesome buildings, rare books in its libraries and it produced outstanding men of science and culture. Al-Hakam II was its most learned Caliph who founded 27 schools, endowed chairs in the university of Cordoba whose library was filled with 400,000 volumes, all properly cataloged. Al-Hakams secret agents were active in Islamic countries looking not for gold but rare books in the bookshops of Iraq, Syria and Egypt for the Cordovan library. A passion for books caused some 70,000 bound volumes to be produced each year. **Some shops employed as many as 170 women to copy manuscripts. There were women bibliophiles, women poets, the best known of whom was Saffiyya of Seville. (2)**

Women played a distinctive role in the shaping of Cordoban society. There were women poets, philosophers, and grammarians. Labbanah was secretary to Talib, chief librarian of al-Hakam's famous library. Fatimah was an elegant writer who traveled in distant lands in search of manuscripts and rare books for the imperial library. Many women earned their living by working in the offices. Aisha (d1010) was the daughter of Prince Ahmad of Cordoba, who had her private library. She wrote many books. Hafsah , daughter of Hamdun, was a native of Guadaljara, was the most illustrious poet of 11th century. She gave lessons in the art of calligraphy. Maryam, daughter of Yaqoob al-Ansari, who lived to a great age in Seville in 11th century, taught poetry and literature. Princess Wallada, daughter of Muhammad III al-Mustakfi, was famous for her poetry. Her home in Cordoba was the meeting place of scholars and savants of the city. She was a rare beauty, Ibn Zaydun, composed poems in her praise. Safiyyah of Seville was a distinguished orator, and poet. She was an excellent calligrapher also. Umm al-Naha was lawyer. There were mosques and fountains built in their names. (*Muslim Spain, page 36, Imamudin, Leiden 1965*)

Cordoba had 37 other libraries, numerous bookstores, 800 public schools, 600 mosques, 150 hospitals, 900 public baths and 80,000 shops. People of this city walked on paved streets while people in Paris & London were trudging on muddy streets, dark alleys and bathing was viewed as heathen practice. (3). It was the first city with streetlight in Europe. It is stated that Caliph Abdur Rahman III maintained diplomatic relations with Emperor of Constantinople, the Pope, Kings of France, Slav countries and King of Germany, Otto the Great. Christian potentates paid homage to the Caliph of Spain and deemed it a great honor if he should allow his hands to be kissed by their ambassadors. ( 4).

**Cordoba was luminous center of intellectual activity, home of highest civilization, bearer of torch of enlightenment. It served as a bridge for transmitting elements of Islamic science & culture to Europe. Its university attracted foreign students in huge numbers just as Harvard or Oxford attracts today. Princes and aristocrats flocked to its hospitals for medical treatment like Sancho, prince of Leon who visited this city in 960 to be treated for an incurable disease. The contrast in intellectual activity between Europe and Spain can further be gauged by the fact that in the ninth century, the largest library of Europe was in the monastery of St. Gall boasting 36 volumes.**

### Arabic books into Latin

It is a fact that European renaissance of 12th century came about through the acquisition of scientific knowledge of Muslims by European men of learning. This was achieved by translating Arabic scientific texts into Latin. It was in Spain and Sicily that majority of these translations were made. This process started in 10th century when French scholar Gerbert (later Pope Sylvester II 999-1003) spent three years at a monastery in Catalonia studying mathematics and astronomy from Arabic books. (5)

Toledo became the center of translation movement in the eleventh century. Two outstanding translators of this movement were Robert of Ketton, & Peter the Venerable who translated Noble Quran into Latin in 1142 AD. Many Jews took part in this intellectual activity by virtue of their proficiency in Arabic, Hebrew and Latin. Abraham ben Azra (1092-1162) was one such Jewish scholar. Several European scholars like Englishman Adelard of Bath, &

Michael Scot traveled to Spain to be part of this intellectual movement. From Italy Gerard of Cremona (d1187) traveled to Islamic Spain to learn Arabic and ended up spending the rest of his life in Toledo. Gerard was to this translation movement what Hunain bin Ishaq was to $9^{th}$ century translation movement of Baghdad. He translated some 71 Arabic scientific works into Latin.

It was by the middle of thirteenth century that the bulk of Arabic books in mathematics, medicine, astronomy, philosophy were available in one common language of Europe, Latin. The founder of translation movement was a Spanish scholar Archbishop Raymundo (d 1151). Besides these scientific works Arabic literary generes like stories, proverb, humor, wisdom, & novels were rendered into Latin as well. In this connection famous Arabic books like *Kalilah wa-dimnah, Sindbad, Barlaam and Josephaat* can be cited. The translations of these books exerted a strong influence on Spanish literature. Spanish Muslim scholar Ibn Hazm's book ***Doves Ring*** definitely influenced the European literature. Surprisingly many scholars used the word *'Libro'* in the title of their books, just as Muslim authors had used word Kitab (book) or Risalah (treatise) in the title of their works.

Islamic Sicily

Some of the books written by Muslim scientists were translated by Jewish scholars because "they moved among (diverse cultures) like fertilizing subterranean streams" ( Age of Faith, page 910). Moses ibn Tibbon translated Euclids book *Elements,* Avicennas Canon, Razis Antidotary, and Averroes commentaries on Aristotle. Hebrew medicine received stimulus through the translation of ar-Razi's *Kitab al-Mansuri* by Shem Tob in 1264. Ibn Zuhrs book on medicine Taysir was rendered into Hebrew entitled *Aid To Health* in 1280.

At Toledo Archbishop Raymond organized a team of translators, many of them were Jews who knew Hebrew, Spanish, Arabic and Latin. In Sicily rulers like Carles of Anjou employed Faraj bin Salim who rendered into Latin ar-Razis *Liber Continens.* In Sicily Arab influence in the organization of the Norman court was so great that three Norman kings assumed Arabic titles; ROGER II called himself al-Mutazz billah, WILLIAM I was Hadi biamrillah and WILLIAM II was al-Mustaeez billah. These titles appeared on their coinage and in their inscriptions.

King Roger II (111-1154) was the most illustrious ruler of Sicily. All decrees of his court were issued in three languages Latin, Greek and Arabic. The decrees which he did not sign himself bore his motto in Arabic that was based on Quranic verse 16:122. On various documents he called himself al-*Malik al-Muazzam al-Qiddis* ( the great and holy king). The crown he wore was of a Byzantine model, but his famous mantle, still preserved in Vienna, was that of an oriental emir with Kufic inscriptions embroidered on it. All his physicians were Arab Muslims, his court officials included **Janibs** ( aides de camp), **Hajibs** ( chamberlains) **Silahis (**equerries) and **Jamadars** ( wardrobe attendants). Al-Idrisi was the eminent geographer in Sicily who drew maps of the earth for Roger II in which he used methods of projection to pass from the spherical shape of the earth to the planisphere that were very similar to those used by Mercator four hundred years later.

William I (1154-1166) and William II appeared more Muslims outwardly than Roger II. Both spoke Arabic fluently. William I had a bodyguard of Negroes commanded by a Muslim. William II resembled a Muslim monarch. Women of Palermo followed the fashions of Muslim women, were veiled, wore oriental ornaments, put henna on their fingers, and wrapped their cloaks around their bodies.

The highest dignitary in the bureaucracy had the Arabic title **Amirul Umara**. All financial records and registers were maintained in Arabic. In administration many terms were Arabic such as IQLIM ( for a military district), as well as terms for various offices such as **sahib, katib and amil**. Muslim soldiers were recruited in the army, there were Arab military engineers who built siege towers. King Roger II employed Arab engineers in the fortification of garrison town *of Bari.*

It is reported that Caliph Harun al-Rahsid sent to King of France Charlemagne an ingenious water clock. The first clock to appear in Europe was that sent by Sultan of Egypt in 1232 to Emperor Frederick II of Sicily. It resembled a celestial globe, in which the sun, moon, and planets moved, being impelled by weights and wheels so that they pointed out the hour, day and night, with certainty. (Short History of Science, by Sedgewick, page 321, 1939 NY. )

**Influence of Islamic Philosophy**

In 1215 King Frederick II became Emperor of Sicily. Frederick was very attracted to Islamic scientific works. It is said that he adopted Islamic costume, customs, and most importantly he was a great admirer of Muslim philosophers. There were a large number of Arabic books in his library. He also corresponded with savants of Islamic sciences. Ibn al-Jawzi, an Arab philosopher gave him lessons in logic. In 1224 he founded a university at

Naples and made it a foremost center of introducing Arabic science to Europe. From this university Islamic influence spread to Italy, Germany and the Provance. Also at this University various works were rendered into Latin. The intellectual luminary in his court was Michael Scot who was the connecting link between Sicily and the translation center of Toledo. On his advice Michael Scot went to Toledo and translated Ibn Rushd's commentaries on Aristotle into Latin. Within a span of 50 years all the philosophical works of Averroes were translated. Ibn Rushds book *Tahaftul* T*ahafah* was rendered into Latin in 1328. In medicine his book *al-Kulliyat fi Tibb* ( Colliget) was also translated. Charles d'Anjou was another Sicilian king whose patronized the translation of ar-Razis encyclopedia in medicine Kitab al-Hawi (Latin *Continens*) .

It should be mentioned that St. Thomas Aquinas received his education at University of Naples. He was the first scholar who made extensive use of all Arabic commentators. He regarded Ibn Rushd as the best exponent of text of Aristotle and a grand master in logic.

In France University of Montpellier was center of medical studies during the Middle ages, it was founded by Arab physicians who were driven out of Spain. The Greek medical texts used here were translated from Arabic versions . In 1340 Canon of Avicenna was included in the syllabus. There were lectures given on Arab physicians. It was only in 1567 that Arabic medical books were struck off the list of books required for medical examination.

All the books of Islamic philosophers were rendered into Latin, among them al-Kindi and al-Farabi, but it was Avicenna and Averroes who exerted the greatest influence on European thought. We find traces of Ibn Sena's philosophy in almost every European philosopher. His distinction between essence and existence was widely adopted. His view that God was the Creator and his ideas of divine Providence also survived. It was Spanish scholar Gundisalvo who translated Avicenna's books into Latin. At university of Padua (Italy) Canon of Avicenna and medical treatises of Averroes were taught. In 1472 an edition of Ibn Rushd's commentaries was published from Padua ( 7). Ibn Rushd's keen analyses won him the title **the Commentator** in Europe. He defined philosophy " as an inquiry into the meaning of existence and believed that God is the order, force and mind of the universe". Unfortunately many of his works were burnt to ashes but the Hebrew translations luckily survived.

Modern research has revealed Islamic sources for Dante's ideas also; the description of hell in the Quran, story of Prophet of Islam's MIRAJ or spiritual journey to heaven, the tour of heaven & hell in Abul ala alMuarri's book *Risala al-Ghufran*, and Ibn al-Arabi's book *Futuhat Makkiya* which has drawn diagrams of the hereafter, described heaven and hell beneath Jerusalem, divided heaven & hell in nine levels & choirs of angels surrounding the Divine Light- all are depicted in Dante's infamous book.

**Agriculture**

The Muslims were experts at sinking wells, and from Syria they brought the noria, or the lofty waterwheel. They introduced sugarcane, *apricots, almond, alongwith cumin, henna and saffron. They established the mulberry tree and the silkworm.*

Islamic irrigation system and novel methods remain the basis for agriculture in parched land of Spain and Portugal. Muslims in Spain raised the level of agriculture where rainfall was very little. They improved agricultural techniques on the basis of knowledge they had gained in the Middle East. There are many words pertaining to irrigation methods that are derived from Arabic. The agricultural methods of Spanish Muslims were revealed by the great Italian engineer Juanello Turriano, who came to Spain to study the hydraulic and agricultural techniques of $11^{th}$ century Andalusia to solve the problems of sixteenth century Italy.

Muslims introduced plants in places where there was enough water supply; sugarcane, rice, apricots, cotton. Even the English words are derived from Arabic like *sugar, syrup, sherbet, elixir, mattress, muslin, satin, bazar, caravan, cheque, tariff, magazine, barge, cable, admiral.*

**Glass and metalwork**

The luxurious life of Islamic Caliphs in Spain can be gauged by the splendid structures of Alhambra in Cordoba, and Alcazar in Seville. The ceramic industry was developed and tile - painting was introduced from the Middle East. Arab craftsmen produced metal vessels or shapes of animals in brass. Cordoba was full of expert jewelers, silversmiths, and goldsmiths. Crystal was manufactured in this splendid capital of the world in ninth century. Elegant bookbinding was done in decorative leather.

Spanish words for architect ( alarife ) and mason ( albanil), castle (alcazar )bedroom (alcoba) , door-knocker ( aldaba), paving tile (baldosa) are derived from Arabic. A number of Europeanized names of textile products are witness to the fact that they originated in the East, Muslin ( from Musul, Iraq), damask ( from Damascus, Syria), baldachini ( from Baghdad) fustian ( from Fustat, Egypt) Tabis ( from an Iraqi family ) and Tafetta ( from Persian Tafta).

They brought to Spain the skill to build a castle that carried the mathematics of defense to an unsurpassed degree. In the 9th century they introduced the best entry, a single turning at right angles to the gate which exposed the attacker in a confined space through a hole in the vaulting. ( 8)

In Cordoba there were schools of ivory and woodcarving, ceramics, glass and metalwork. Cordovan artists in glassware and brassware passed on their craftsmanship to Europe. This city was popular for its weaving also. Silk textiles rich in color and geometric designs, found favor with European royalty. European weavers adopted Islamic designs in 12th century, and used elegant Arabic script for decorative purposes. Tanning leather was also popular industry. As it passed onto Morroco, France and England it left behind words like morroco, cordovan, and cordwain. (9) They founded trade guilds, craftsman, potters, weavers were all rewarded. The art of crystal was discovered in the glass workshops of Cordoba. Silver and gold thread was spun for brocades, thereby filigree work developed.

Toledo and Seville were also centers of metalwork, notably cutlery and sword blades. Valencia was home of colorful ceramics. Ceramics was introduced into France from Spain. Silk fabrics with rich floral and geometric designs were in demand for church vestments and aristocratic robes. Horse-shoe arch was first developed in Cordoba for structural designs.

In technology Muslims were well versed. They were acquainted with the use of gunpowder and artillery before Europe. They derived from China knowledge of paper, and as early as 650 AD, made silk-paper in Samarkand, and by 706, cotton paper was manufactured in Mecca. Arabs made woodcuts for the ornamentation of paper manuscripts. The art of printing was brought through Middle East to Europe.

Paper manufacturing was yet another vital industry that triggered the European awakening. Paper industry was introduced into Spain from Islamic East in 12th century. The city of Shatiba (Jativa) in Spain was the center of industry. Paper mills were introduced into France from Spain as early as 1189. In Italy paper arrived through Islamic Sicily. Paper-making was thus the most beneficial Islamic contribution without which printing from movable type would not have been possible. The significance of printing in the dissemination of knowledge cannot be overestimated.

The Arabs are credited with the invention of Mariners Compass, the first reference to it in Europe is ascribed to Alexander Neckam (1157-1217).

**Music**

The Muslims invented various types of instruments. Instrumental music was played at military occasions. There are many books produced on musical theory. Seville was famous for musical instruments. Arabic names of the lute (al-Ud) , guitar ( Ar. Qitar), rebeck ( Ar al-Rabab) , tambourine( Ar. Tamboura) , naker ( Ar, Naqqara) and organ ( Ar. urghun) suggest that these came to Europe from Islamic countries. The guitar, which was derived from Arab lute, is still a favorite instrument in Spain. Ziryab, the famous black musician added the fifth string to the lute.

Famous Muslim philosopher al-Farabi was an accomplished lute performer, in fact he was the greatest writer on the theory of music during the middle ages. He produced an authoritative work *Kitab al-Musiqi al-Kabir*. Famous physician ar-Razi also produced a work on musical theory. Al-Farabi's translated works together with the musical studies of ibn-Sina and ibn-Rushd were used as textbooks in Western Europe. (10) Alkindi was another musician who treated sick people with music. Imam al-Ghazzali favored assemblies of *al-sama* (devotional music and song ).

Abul Hassan Ibn Nafi**,** nicknamed **Ziryab (d857)** was the leading musician of Spain. He migrated from Baghdad where he received his training from famous singer Ishaq al-Mausili. In Cordoba he was showered with gifts, an estate, and a salary of 200 dinars ($1000) per month.

He was an arbiter of fashion and taste in Spain. He made popular a short haircut instead of wearing it long and parting it on the forehead. He revolutionized the cuisine with recipes from Baghdad. There was a dish called *takalliya-i-Ziryab*, made of meatballs and paste fried in coriander oil. From then on food was served as separate courses beginning with soups, continuing with entrees & meat, finishing with desserts made from nuts, honey & fruit. He instructed that meals be served in crystal glass instead of goblets of silver or gold. It is likely that the order of courses we follow today goes back to this outstanding Muslim. He was the first intellectual to believe cooking to be both an art and a serious science. He set standards of refinement in deportment and table manners. He introduced beauty salon, toothbrush, and toothpaste. (11) He introduced jubbahas made of colored silk. Before his time King's clothes were washed in rose water, he taught people to use salt in washing clothes. All these innovations became fashion not only in Islamic Spain, but throughout Europe. He was called Ziryab (black crow) because of his dark skin.

Ziryab was also a poet and first rate scholar of his age. He was learned in philosophy, history, geography, and medicine. It was he who laid the foundation of scientific fame of Cordoba. He introduced the Arabic translations of works of Aristotle in Spain.

John Glubb states in his book that " the state robes of medieval German emperors often bore Arabic text, interwoven with the rich designs of the fabrics."(12) .

**Medicine**

Arabs in Spain had a passion of beautiful gardens. They were interested in medicinal plants. Spanish scholar Ibn al-Awwam wrote a treatise on agriculture giving 584 varieties of plants together with instructions as to their cultivation. Several books of medicine were translated into Latin and in some cases were used as textbooks in medical schools of Vienna, Montpellier, and Salerno.

Islamic medicine reached its zenith during 9th and 10th centuries. At that time intellectual life was deeply rooted in the universities of Baghdad, Kufa, Samarkand, Damascus, Bokhara and Cairo.

In Islamic Spain famous universities sprung up in Cordoba, Seville, Toledo and Almeria. These universities often included large blocks of buildings, and were associated with hospitals. They had residence for teachers as well as students and had excellent library facilities. Theology, philosophy, physics, astronomy, and medicine were chief subjects. Spanish universities enjoyed so great a reputation that students from Europe came for higher education. Cordoba had 40 hospitals.

Translation of medical works from Arabic introduced into European languages such words as *julep, rob, syrup and soda*. Latin *Soda* is a corruption of Arabic word meaning headache; it was used in that sense and latter used for a headache remedy. (13) Professor Watt states that European medicine in the fifteenth and sixteenth centuries was still little more than an extension of Arab medicine. (14). Franz Wustenfeld has enumerated three hundred Muslim medical writers while other historians have enlarged the list.

Some of the prominent Muslim physicians who wielded decisive influence in the revival of European medicine are; Hunayn ibn Ishaq (809-877) was a gifted physician and a dominating figure of translation academy of Baghdad. Besides composing his own works, he translated 139 scientific works into Arabic,

And Syriac. In medicine he wrote a manual in the form of question and answer *Questions on Medicine* and the earliest treatise on ophthalmology *Ten Treatises on Medicine*. Both were translated into Latin.

Isaac Judaeus (855-955) his numerous works in medicine *On Fevers, On simple drugs and ailements, On Urine, Guide for Physicians* were translated into Latin by Constantine the African in 1080. Robert Burton (1577-1640) quoted him freely in his book *Anatomy of Melancholy*. Ibn al-Jazzar was Isaac's pupil whose work *Provision of the Traveler* was translated into as *Viaticum* by Constantine the African, but the translator put his own name as the author of this work.

Zakariya ar-Razi: His book al-Hawi (the comprehensive book) was translated into Latin *Liber Continens* in 1279. This encyclopedia of medicine was printed under the title Continens for use as a textbook, the last edition appeared in Venice in 1542. His other book *Kitab al-Tibb al-Mansoori* was translated as *Liber medicinalis Almansoris in* 1480, its last edition was published in 1890. His famous book on smallpox *al-Judri wal-Hasba* was translated as "de Peste de Pestilentia". It was published in English from London in 1848.

Ibn Sena: His magnum opus in medicine *al-Qanoon fil Tibb* was published Canon of Medicine in 1170, His other books translated were Sanatio in 12th century, and *Kitab al-Shifa* (Book of Healing) or Latin Sufficientia. All of his 16 books in medicine were translated in several European languages. There have been about 30 Latin editions of his *Canon*, fifteen appeared during the 15th century. It became the medical textbook of choice in European universities, and was used until after 1650 in medical schools of Louvain and Montpellier. It has been claimed that it is the most studied textbook in all history. (15)

Abal Malik Ibn Zuhr: (d1162) His book *Kitab al-Aghziya* was translated in 12 century as well as *Kitab al-Taisir*,( Alleviation of disease) & Kitab al-Iqtisad.

Abul Qasim az-Zahrawi (d 1013) wrote a 13 volume medical encyclopedia called at-*Tasrif* which was translated into Latin in 1497, an edition printed at Basel in 1541, Oxford 1778. Surgical tract of this book was first translated by Gerard of Cremona, was used as a textbook in surgery for nearly five hundred years in medical schools of Salerno, & Montpellier. His other medical work is entitled Liber Servitories which was published from Venice in 1479. This work represents an early example of chemistry employed in medicine. His method of presentation surpassed Galen.

Ibn Rushd : (1126-1198) His book in medicine *al-Kulliyat fi Tibb* was translated as *Colliget* in 1255 by a Jewish scholar Banacase of Padua . His other book al-Taisir was rendered into Latin and several editions appeared in Europe. Needless to say that he was the first physician to explain the function of the retina, and to recognize that an attack of smallpox confers immunity for the rest of life. Colliget was used as a textbook in European medical schools for several centuries.

Ibn al-Haisham : His master-piece in Optics *Kitab al-Manazir* was rendered into Latin as Opticae Thesaurus in 12th century and used by many prominent scientists.

Ibn al-Nafis: (1208-1288) This Syrian medical doctor wrote a book Mujaz al-Qanun – summary of Canon - which was based on Avicenna's Cannon. He made significant contributions to the circulation of blood in human body. Three hundred years later this discovery was credited to Michael Servetus. Al-Majusi (d994) or Haly Abbas wrote for his royal patron *Kitab al-Maliki* ( the Royal Book) which was translated into Latin. It was a treasure house of practice of medicine. It advanced the theory that in delivery the child does not come out by itself but is pushed by the muscular contraction of the womb.

Prof. Neuberger states " *in the persons of Arabic physicians the East was once again teacher of the West. Grateful for all they owed to the Nestorians, the Muslims gladly threw open to the West portals of scientific medicine. " ( 16)*

### Chemistry

Chemistry was the original invention of Muslims. Jabir Ibn Hayyan, a native of Kufa, Iraq is considered to be father of al-Kimiya (chemistry) while Zakaria ar-Razi was unquestionably the greatest chemist of medieval world. Jabir wrote close to 100 treatises in chemistry, many of which were translated by Berthelot. His other books translated into English are Book of Kingdom, and Book of Balance.

Professor Hitti has described his books as "the most influential chemical treatises in both Europe and Asia." Razis book *Kitab al-Israr* deals with the preparation of chemical substances. He classified mineral substances into vegetable, animal and mineral.

Chemical vocabulary abounds in words of Arabic etymology: *alcohol, alembic, alkali*, *antimony, & tutty. Soda* is a corruption of an Arabic term meaning splitting headache; it was first used in Latin in that sense and subsequently used for a headache remedy.

Islamic Spain's well-known mathematician Abul Qasim al-Majriti (d1007) wrote two books in chemistry *Rutabatul Hakim* (The Sage's Aim) and *Ghayatul Hakim* (the Aim of the Wise). The latter book was translated into Latin in 1250 under the title *Picatrix* and became a mainstay of chemistry literature during the middle- ages.

Muslims loved travelling, they penetrated as far East as Borneo and China. They introduced a large number of non-chemical medicaments into their materia medica which include *alum, borax, camphor, cloves, myrrh, nutmeg, sandalwood, musk, tamarind, nitre, and soda.*

### Chess

Chess was introduced into Europe via Alandalus. The game originated in India and symbolized the conflict between the forces of good and evil. Arab found this game when they conquered Persia and for them it represented opposing armies. The elephants (bishop), castles & knights were horsemen, and the pawns the infantrymen. Many names and terms of this game used even today are Persian/Arabic in origin. For example rook is derived from **rukh,** and checkmate is from Persian **shah-mat** meaning the king is dead. Strangely the German terms for this game are more close to Persian.

### Physics

Some of the eminent physicists of medieval Islam were Ishaq al-Kindi, Jahiz, al-Razi, al-Haisham, and al-Biruni. Al-Kindi wrote close to 200 books, of these one is on optics, one on reflection of light and some on specific weight. Gerard of Cremona rendered many of his works into Latin. His treatise on optics influenced a great scholar like Roger Bacon.

Al-Khazini explained that density of water was greater to the center of earth. His book *Mizanul Hikma* is a brilliant work on table of densities. Roger Bacon is said to have based his proof of density of water on Khazini's hypothesis. Albiruni's achievement in physics is his determination of weight of eighteen stones. His book *Kitabal Jawahir* deals with various types of gems.

Burkhardt states that physics of Ibn Bajja (Avempace) were reaching Galileo by way of the writings of Avveroes. His is the well-known formula whereby the speed of a moving body is equal to that of the moving force, less the environmental resistance. He is likewise the author of the important thesis that the force that causes a fruit to fall from the tree is the very same as that which moves the celestial bodies (17).

Will Durant is of the view that Ibn al-Haishams masterpiece in Optics was "*thoroughly scientific in its method and thought. He came so close to discovering the magnifying lens that Roger Bacon, Witelo and other Europeans three centuries later based upon his work their own advances toward the microscope and telescope. We could hardly exaggerate the influence of Haisham on European science. Without him Roger Bacon might never have been heard of, Bacon quotes him at almost every step in that part of Opun Maius that deals with optics & Part VI rests almost entirely on the findings of this Cairene physicist. As late as Kepler & Leonardo European studies of light were based upon al-Haishams work." (18)*

**Astronomy**

In the twelfth century Arabic was the scientific language of the world. In Europe all the astronomical instruments and tables were imported from Islamic countries or were modeled after Islamic originals.

Muslims made significant contributions in this field. All the terminology used in Europe during the medieval times was Arabic in origin. Islamic world produced some of the finest astronomers like al-Batteni, al-Farghani, Albiruni, al-Zarqali, al-Tusi, and Ulugh Beg. Books written by these eminent men and their tables of stars were translated. For instance Albatteni's book was translated in Latin *De Scienta Stellarum* in 12th century while his al-Zij was published from Rome in 1899. Al-Farghani's book was rendered into Latin in 1170.

Al-Zarqalis *Toledan Tables* were translated in 12th century. He invented an astrolabe **Safiha** details of which were translated into Latin & Hebrew. Copernicus expressed his indebtedness to Batteni & Zarqali in his book *De Revolutionibus Orbium Clestium* and quoted their works numerous times.

Nasiruddin al-Tusi was another leading astronomer of $13^{th}$ century. His book *Figura Cata* was translated in $14^{th}$ century. Sultan Ulugh Beg's Tables of Planetary Motions were also rendered into Latin in $12^{th}$ century. Ishaq al-Birtuji was a Spanish astronomer who lived in Seville. His book on astronomy *Kitab al-Hayah* was translated into Latin & Hebrew in $13^{th}$ century. The last Latin edition of his book was printed in 1531.

Muslim astronomers have left on the sky traces of their knowledge, which can be seen in the names of various stars. *Acrab(scorpion), Algedi (kid), Altair (flyer), Deneb ( tail), Pherkad (calf*) . Then there are technical terms that are Arabic in origin as azimuth, nadir and zenith.

The Muslims geographers believed that earth was a sphere, this doctrine was fundamental to the discovery of the New World. An exponent of this doctrine was abu Ubaidah al-Balansi ( of Valencia)who flourished in the first half of tenth century. The Hindus believed that the known hemisphere of the world had a centre or "Summit" situated at an equal distance from the four cardinal points. This ARIN theory found its way into a Latin work published in 1410. From this Christopher Columbus acquired the doctrine which made him believe that the earth was shaped in the form of a pear, and that on the western hemisphere opposite the ARIN was a corresponding elevated centre. ( Hist of the Arabs, page 570, by P.K. Hitti, 1946)

**Expressions in Spanish**

In Spain continued use of some expressions reflects the survival of Arab and Islamic manners. When a Spaniard writes a business letter he will often sign it **q.b.s.m. or q.b.s.p**.( que besa sus pies) which means may I kiss your hand or may I kiss your feet. This expression echoes the old custom of greeting or taking leave of a honorable man by kissing his hand or in the case of royalty the feet. It is good manners in Spain to convey a married woman's hand to lips when a man meets a lady.

When welcoming a guest to the house, a man says " *ha tomado vd. possession de su casa*" which is a rendering of Arabic expression **"al-Bayta bataka**" ,this house is your house. Also in Spanish countryside when a peasant woman offers tortilla on a train or bus – the invitation reflects the Arab habit of sharing with others what you have. Then if a beggar in Spain begs by telling a story of ill fortune, he gets the reply *"ude Dios le ay*" which in Arabic is **Allahu Aatika,** may Allah help you. When a Spaniard makes plans and ends with " **si Dios quiere**" ( if God wills) he is invoking the Arabic phrase *insha-allah*. Crowds at bullfights shout with excitement "OLE" which is derived from Arabic wa-allah ( for God's sake).( 19)

All the luxury of Europe came in by way of Spain. Fine materials such as silk, cotton, velvet, satin ( Ar. zayton) damask, cashmere, muslin, chintz, taffeta, gingham, chiffon, cramsoiy (Ar. girmazi), and mohair came from the East as did such article of dress shawl, chemise, tiara, mask and turban.

In house decoration such items as carpet, tapestries, mattresses, sofas, alcoves, and baldachins ( from Baghdad) are Arabic in origin. The names of utensils such as carafe ( Ar. gharrafa) and jar ( Ar. jarrah) are also Arabic in origin. Among table *fruits mulberries, pistachios, figs, citrons, apricots, watermelons, orange, peaches, lemons, damsons (from Damascus); among vegetables artichokes, asparagus, spinach and eschalot ( from Ascalon, Syria); among flowers tulips, lilacs, roses and jasmine*. All spices, cosmetics, and many dyes including indigo ( from India) are Eastern in origin.( 20) .

First man to fly

Caliph Abdur Rahman II had attracted men of letters in his capital, among them was **Abbas ibn Farnas who was a renowned experimentalist. He discovered a formula for making glass and constructed a heavenly globe with simulated lightening and thunder. He also constructed the first flying machine by attaching feathers to light frames functioning as two wings. He remained airborne for a short period. (21)**

### Ophthalmology

Eye disease in the Middle East was prevalent, consequently Islamic physicians took special interest in this field. Technical words as lens, retina, cornea, & cataract are derived from Ibn al-Haisham's description of the various parts of an eye.

| | |
|---|---|
| Saqb al inabiyya | - Pupil |
| Al-qarniyya | - Cornea |
| Al-bayZiyya | - albugineous humor |
| Al-jalidiyya | - crystalline humor |
| Al-zajajiyya | - vitreous humor |
| Al-asab al-basari | - Optic nerve |

Egypt was major center in the development of Islamic ophthalmology, it reached its peak during the rule of Caliph al-Hakim. Alhazen showed in his book that light falls on the retina in the same way it falls on a surface in a dark room through a small aperture. He also correctly stated that image made on retina is conveyed through optic nerve to the brain. He transformed this science in his monumental work *The Book of Optics*. He drew a diagram of an eye in which the lens is central and being the essential organ of vision the optic nerve ran directly into it.

Ar-Razi, a prolific writer and a commentator, recognized that the pupil of eye reacts to light. His magnum-opus *al-Hawi's* famous ninth part was principle textbook of pathology during the middle ages in Europe. Ibn Sena's classical work, *The Canon of Medicine* dominated the medical thought in the western world for nearly five centuries. He described the exact number of muscles of the eyeball, namely six. Muslim physician's knowledge in this field made possible the removal of cataract. Ibn Rushd (1126-1198) wrote extensively on optics and suggested that the retina and not the lens is the photoreceptor in the eye, a revolutionary hypothesis which was not revived until the time of Kepler.

The interesting thing about Islamic ophthalmology is that all anatomical illustrations were drawn in one plane. They remain the oldest extant attempt to visualize the eye and its connection to central nervous system in graphic form. The oldest such diagram is found in Hunain Ibn Ishaq's *Ten Treatises on the Structure of the Eye,* which was drawn in 860. The anatomical conceptions of the eye were based on these diagrams in Europe for many centuries. They were accepted in optical works of such worthies as Roger Bacon, John Peckam and Vitello in $13^{th}$ century. They even influenced anatomical diagrams made by Leonardo da Vinci.

Ali Ibn Isa (d1031) or Jesu Hali was an eye specialist who wrote '*Tazkara al-Kahlain'* which in fact is an encyclopedia of human eye in three volumes. The works describes 130 eye diseases, gives 143 herbs and medications which are useful for eyes. The third volume describes internal eye diseases that are not apparent externally. A Latin translation of this work appeared in 1499, a French edition in 1903 and a German in 1904. (22) Az-Zahrawai (d1009) was an outstanding surgeon in Islamic Spain. His book on surgery *at-Tasreef* describes in detail the cataract operation.

### Influence in Mathematics

Arabic word for naught is sifr from which cipher (zero) is derived. Arabic numerals, operating on a decimal system in fact revolutionized arithmetic. *Algorismus,* a corruption of name of al-Khwarizmi, was the Latin term for an arithmetical system using Hindu numerals. Someone credited the Arabs for inventing this system, hence they are called Arabic numerals.

Al-Khawarzimi's book *Hisab al-jabr wal-Mu*qabala was translated into Latin ( *Liber algebre et almucabola)* as well as his book *Hisab al-Hindi*. These books are preserved in the university library of Cambridge. His ZIJ (astronomical tables) was translated into Latin in 1126 by Adelard of Bath and served as a basis for all future planetary tables. A manuscript survives at the Bodleian Library, Oxford.
Algorism entered into European vocabulary, which a corruption of his name.

Many books on mathematics written by such giants as al-Kindi, Musa bin Shakir, Ahmad ibn Yousuf were translated by Gerard of Cremona in 12th century. Abu Kamil's book *Kitab al-Tareef fil Hisab* was the basis of Italian mathematician Fibonacci's books. Hajaj ibn Yousuf ibn Mattar (d833) translated Ptolemy's book on astronomy Megala Syntax's as **Kitab *al-Majisti (Almagest),*** which served as a source for all future editions.

Famous Muslim astronomer al-Batteni's treatise was translated into Latin as "Die *Scienta Stellarum*" . A copy of this book is preserved at the Vatican library. Copernicus has expressed his indebtedness to al-Batteni in his book "*Die Revolutionibus*". Robert of Chester (d.1149) by adapting his Zij brought Arabic trigonometry to England. Abul Wafa's name is linked with one of the fundamentals of astronomy that of the third inequality of moon. Unfortunately this discovery has been wrongly attributed to Danish astronomer Tycho Brahe. Ibn Younus, the Egyptian astronomer invented pendulum
and the sundial. He was the first person who studied the isometric oscillatory motion of a pendulum – which later led to construction of mechanical clocks. ( 23 )

Ibn al-Hiasham's book *Opticae Thesaurus* was a source of inspiration to European giants like Roger Bacon, Newton and Kepler. His studies led him to propose the use of camera obscura.
He came so close to discovering the magnifying lens that Bacon, Witelo and other European scientist three centuries later based their advances toward inventing microscope and telescope. Holland's scientist Willbrod Snell rediscovered his law of refraction. Al-Haisham also enunciated "*that a ray of light, in passing through a medium, takes the path which is easier and quicker*." This is now
called Fermats principle of least time(24). It is stated that chapter V of Bacon's book *Opus Majus* is an annotation of *Kitab al-Manazir*.

Al-Tusi criticized many of Ptolemy's theories and presented his planetary model. His criticism of Ptolemy's book *al-Majisti* with regard to anomalies of moon, motion of Mercury & Venus, was a courageous step towards the emergence of heliocentric system of Johannes Kepler. ( 25 ). He observed that a combination of two uniform circular motions in the usual epicyclical construction can produce a reciprocating rectilinear motion. Copernicus later rediscovered this theorem of Tusi.

Az-Zarqali (1020-1087) made an international name by improving astronomical instruments, Copernicus quoted his treatise on astrolabe also.

The first book printed in Westminster, England was The Dichts and Sayengis of the Philosophes in 1477, that was based on an Arabic original *Mukhtar al-Hikam wa-Mahasin al-Kalim by* ***Mubashir*** **ibn Fatik** who flourished in mid eleventh century. ( Islam and the West , page 77, by Prof Hitti, NY)

## F**low of information**

"It is rare, " says Michael Wolf, " *when we can pinpoint where one civilization went on to learn from another, but Muslim Spain provides a clear-cut case. It became the site for the most prolonged and intimate encounter in Europe among Judaism, Christianity, and Islam. In the explosion of philosophical thought triggered during this period, most of the "lost" works of Aristotle, Plato, Hippocrates, Galen, Ptolemy and Euclid were reintroduced into Europe through Arabic translations and the commentaries of Muslim philosophers and scholars. The full extent of this wealth of translations may never be uncovered, but on two points modern scholarship agrees: the works revived in Muslim Spain fueled Europe's renaissance, and the flow of information was all one way* . " ( 26)

All this transfer of knowledge from Islam to Europe served as a catalyst for European scientific revolution. Without Muslim contributions to various sciences European renaissance could not have occurred. New ideas, new theories, new inventions, new construction techniques, new instruments, new methods of transforming metals played pivotal role in the transformation of Europe.

Bibliography:

1. Influene of Islam on Medieval Europe by M. Watt, page 43.
2. Islamic Spain by G. Goodwin , page 43, 1990
3. Capital Cities of Islam by P.K. Hitti, page 154, Professor Ismail Faruqi has provided a different figure: Population 600,000. Shops 92,700. Pub Baths 300. Madrasa 80. Mosques 600. Pub libraries 70. Hospitals 50. 1 university 20,000 students. (Cultural Atlas of Islam,1986, page 319)
4. Muslim Colonies of France and Switzerland by H.K. Sherwani, page 151, Lahore 1951
5. ibid. page 247
6. History of Islamic Sicily, by Prof Aziz Ahmad, pp 63-67, Edinburgh 1975
7. Arabic Thought and its place in History by O'Leary, page 144, 1922
8. Islamic Spain by G. Goodwin, page 14
9. Capital cities of Islam, by P.K. Hitti, page 156
10 Near East in History by Phillip Hitti, page 268
11 Islamic Spain, by Goodwin, page 43
12 Empire of the Arabs, by John Glubb, page 256
13 Near East in History, page 253
14 Influence of Islam, by Dr. Watt, page 68
15 Medieval & Renaissance Medicine by B.L. Gordon, page 201, 1959
16 History of Medicine, by Neuberger, page 383, vol. I. 1910
17 Moorish culture in Spain, by T. Burkhardt, page 166, 1972
18 Age of Faith, by Will Durant, page 288
19 Moors in Spain, by Jan Read, page 236
20 Medieval and Renaissance medicine, page 192
21 Moors in Spain, by Read, page 66, 1975
22 Mussalman Sciencedan ( Urdu) by I.A Nadvi, page 112, 1993, New Delhi
23 Science and civilization is Islam, by Dr. S.H. Nasr, page 17
24 Ideals and Realities, by Dr. Abdus Salam, page 283
25 Albiruni Commemorative Volume, page 566, 1971 Karachi
26 One thousand road to Mecca, by Michael Wolfe ,page 34, 1997 NY

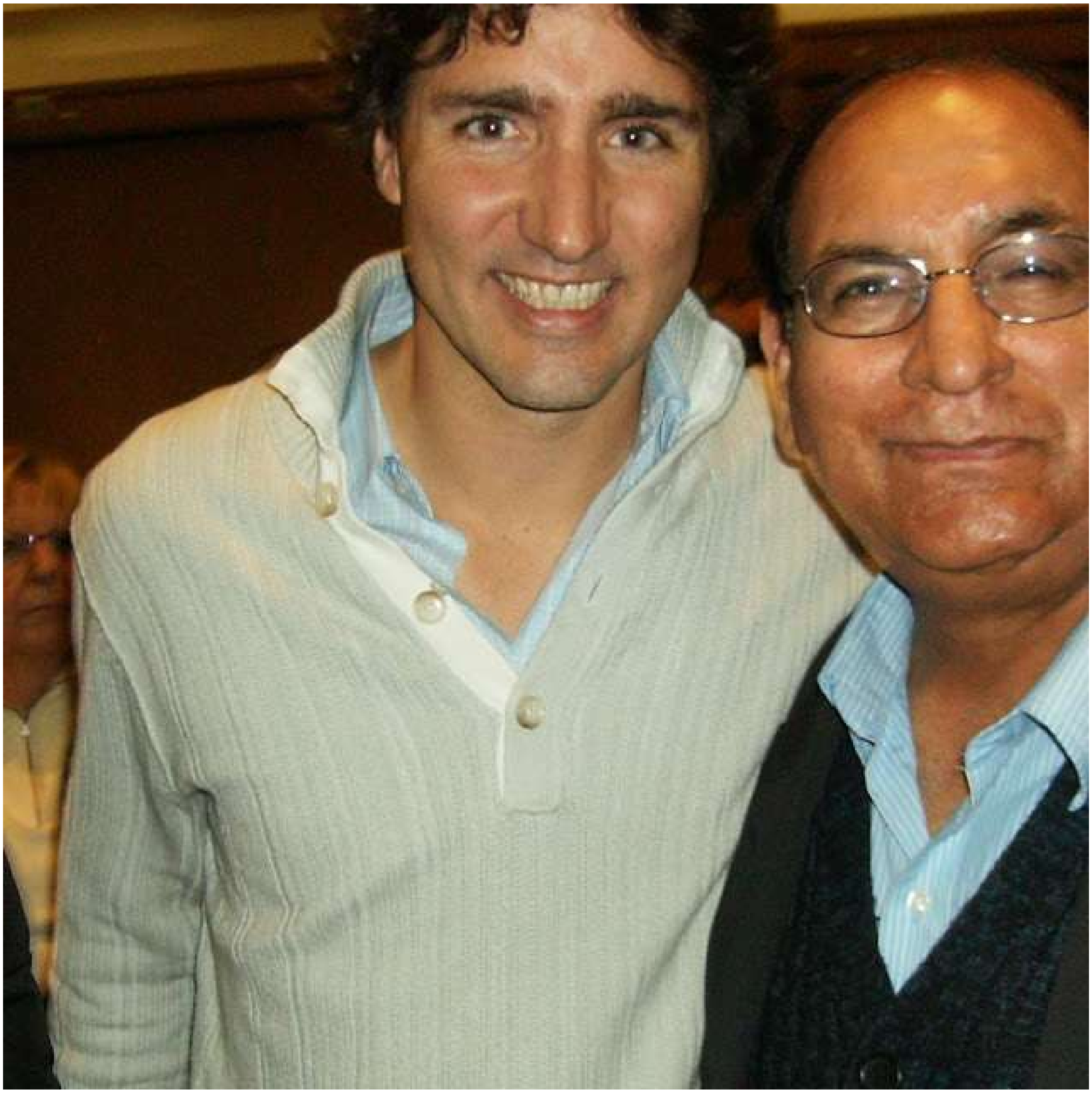
()()()

R-L : Dr Pervaiz Perwazi, eminent writer Hamid Akhtar, and Zakaria Virk – 2010 Toronto


Zakaria Virk with world renowned Iranian author Prof. Syed Hossein Nasr, 2011

Zakaria Virk with Nobel Laureate Prof Abdus Salam, Madison, Wisconsin, USA 1982


R-L Zakaria Virk, Mahmood Sham, Amjad Islam Amjad, Toronto 2014



Zakaria Virk with Honorable Justin Trudeau in 2013, later prime minister of Canada.