Muslim Contribution to Science and Culture

[A BRIEF SURVEY]

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ITRODUCTION

MODERN research has established the fact that the human race built up its civilization some six thousand years ago on the banks of the Shatt al-'Arab and the Nile; whence it spread gradually through various channels all over the world. Knowledge gathered from patient observations, experience and accidental discoveries was disseminated through Khaldia, Babel, Egypt, India and Phoenicia and ultimately reaching Ionia and Greece, found there a most congenial atmosphere to develop and systematize for six or seven centuries before the birth of Jesus Christ.

Greek enterprise in colonization brought the fruits of Hellenic research within the reach of various communities bordering on the Levant. But decentralization imperceptibly led to deterioration and decay and Greece lost her initiation in the cultivation of Arts, Science and Literature. Alexandria and Syracuse upheld, however, for a time the traditions

of Greece, but succumbed eventually to th iron discipline of Rome, which, while it ensur ed order and administration, failed to encour age originality and scientific investigation.

On the downfall of Rome by the Bar barians chaos and intellectual stagnation onc more held sway over the civilized world. Th masterpieces of Greek science and culture la buried in tottering libraries or museum and might possibly have disappeared alto gether from the face of the earth but for th miracle of Arab rise to power and its subse quent patronage of learning.

Islam not only bound the nomadic tribe of Arabia in a common bond of brotherhood it gave them a book, the Qur'ān which taugh them how to lead a life of purity and righteous ness. The beauty of its language and th grandeur of its inculcations inspired the deser people to share the blessings of their faith anc Sharī'at with the rest of mankind.

We are not concerned here with the ter· ritorial conquests of the early votaries o

Islam. These will be referred to in a cursory manner merely to trace the transmission of Muslim culture and learning to distant countries and nations.

After the subjugation of practically the whole of Arabia during the lifetime of the Prophet, and the conquest of Syria, Iraq, Persia and Egypt in the days of the four Orthodox Khalifas, the Umayyad regime (of about eighty-nine years from 661 to 750) brought the whole of North Africa (with extensions into the Iberian Peninsula), Central Asia right up to the borders of China proper, modern Afghanistan, Baluchistan, Sind and parts of the Punjab under Muslim sway. Most of these acquisitions occurred during the time of 'Abd al-Malik and his son al-Walīd, under the generalship of Maslamah, Mūsa ibn Nuṣayr, Muḥammad bin Qāsim al-Thaqafī and Qutaybah ibn Muslim. Had the Umayyads refrained from petty tribal jealousies and, above all, followed in the footsteps of the Orthodox Khalifas as did 'Umar II, they would probably have made further conquests and

certainly continued much longer in power. As it was, they made bitter enemies amongst both the Arabs and the Persians and were finally crushed by Abū al-'Abbās al-Saffāḥ, the champion of the Abbasid cause, in 750, and practically the entire Islamic world (with the exception of Andalusia) passed under the sovereignty of Banī 'Abbās.

The third Khalīfa 'Uthmān had already put together the various *Surahs* revealed to the Prophet and ensured the unalterability of the text and pronunciation of the Qur'ān. The basic principles of Arabic grammar were framed by the great exponen' of Islamic learning, 'Alī ibn Abī Ṭālib. During the Umayyad regime Ḥajjāj ibn Yūsuf introduced at Baṣrah the use of dots to discriminate between letters of different sounds but similar form and of diacritical marks to serve as vowels. Arabic thus systematized and endowed with natural flexibility was ready to assimilate the ideas and expressions of the most fully developed languages of the time, Greek, Sasanid and Sanskrit.

As pointed out by al-Tha'alibī (d. 1038) in *Laṭā'if al-Ma'ārif*, the real opener of the Abbasid regime was Abū Ja'far al-Manṣūr (754-775), the mid-comer was 'Abdullah al-Mā'mūn (813-833) and the 'closer' was al-Wāthiq (842-847), though the dynasty continued till the thirty-seventh and last representative, al-Musta'ṣim, who perished in the sack of Baghdād by Hulagu in 1258. It is not so much for its conquests and military glory that the Abbasid Khilāfat is famous, as for its achievements in peaceful pursuits such as commerce, arts, science and architecture, though the struggle with Byzantium continued intermittently and, on one occasion at least, brought the victorious Abbasid armies to the very gates of Constantinople, humiliating Empress Irene (782)[1] and later enforcing a tax on the person of her successor Nicephorus I (806).[2]

1. *Tabari*, Vol. III, p. 504.
2. *Ibid.*, pp. 696, 709-10.

I

CULTIVATION OF MEDICINE, MATHEMATICS AND ASTRONOMY IN THE ABBASID REGIME

It was al-Manṣūr who built Baghdād near the site of old Ctesiphon on the plan submitted by the Persian philosopher Nawbakht and the astronomer Masha'allah, a convert to Islam from Judaism. Within fifty years of its planning it rose to be the most important city in the world, rivalling Constantinople itself in the grandeur of its royal mansions, number of public buildings, extent of population and volume of trade and commerce. The glowing accounts of its wealth and splendour preserved for us in the pages of *al-Aghānī* by Abū al-Farāj 'Alī ibn al-Ḥusayn ibn Muḥammad ibn Aḥmad al-Quraishī al-Iṣbahānī (897-967) and of *al-Fihrist* by Ibn abī Ya'qūb al-Nadīm al-Warrāq (d. 995) surpass the feeble attempts of

the compilers of *Alif Laylah* to portray the brilliance of the court of Hārūn al-Rashīd.

Al-Manṣūr's illness led to the invitation of the famous Nestorian physician Jurjīs ibn Bakhtī Yashū' of the medical academy of Jundi Shāpūr to the Abbasid court,[1] an event fraught with most far-reaching effects on the future development of the science and art of medicine. The treatment was successful and the Bakhtī Yashū' family flourished for generations in Baghdād as court physicians,[2] awakening a keen interest in their royal masters to promote the study of the masterpieces of Hippocrates (436 B.C.) and Galen (200 A.D.).

The advent of an Indian mathematician and astronomer to the court of al-Manṣūr in 773 with a copy of *Siddhanta* (*Sindhind*, a Sanskrit treatise on astronomy) induced that early patron of learning to get the work translated into Arabic. Muḥammad ibn Ibrāhīm al-Fazārī performed the task with the help of competent assistants, and within a few years Iraq gave birth to a number of astronomers

1. *Fihrist*, p. 296.
2. *Qifti*, pp. 134-35.

who not only mastered all the availab knowledge of astronomy but made origina contributions to it from time to time, righ down to the end of the fourteenth centur Desert life under crystal-clear skies had im pressed on the Arab mind from time im memorial the majesty of the heavens, shinin with countless stars whose configuration they came to know by heart and whose diurnal rotation they utilised to serve as their time-piece. Some of the most eloquent passages in the Qur'ān refer to the grandeur of the stellar world, the regularity of solar and lunar movements among the constellations, the repetition of the phases of the moon and the dazzling brilliance of the restless planets. No wonder that the Arabs and later converts to Islam from other nationalities took so enthusiastically to astronomy and left on it their permanent mark. We shall have occasion to deal with this matter in detail subsequently.

The same Indian mathematician introduced to the Arabs Hindi numerals, their efficient notation and the inestimable impor-

tance of Zero (Arabic Ṣifr). They adopted the methods of Hindi arithmetic unhesitatingly and popularized them all over the world so much that Western Europe until quite recently tacitly believed the Arabs themselves to be the originators of these numerals and their notation.

Among the treasures won from Byzantine cities were Greek manuscripts on geometry, astronomy, medicine and philosophy. Even as early as at the close of the eighth century A.D. we find Abū Yaḥyā ibn at-Baṭrīq translating for al-Manṣūr the major works of Galen and Hippocrates. Several other works like the *Elements of Euclid* and the *Almagest* (Arabic al-Majisṭi) of Ptolemy are stated by Ya'qūbi[1] to have been translated into Arabic at about this time, but evidently they had to be revised by abler translators under the patronage of Hārūn al-Rashīd and his son al-Mā'mūn. For lack of adequate knowledge of Greek these early versions had to be rendered first into Syriac by Syrian scholars and retranslated from that language into Arabic.

1. *Buldān*, Vol. I, pp. 150-51.

Syrian Christians, therefore, played an important part in this intellectual drama. Yūḥannā ibn Masāwayh (d. 837), a pupil of Jibrīl ibn Bakhtī Yashū' and teacher of Ḥunayn ibn Isḥāq, for instance, translated a number of Greek manuscripts into Arabic.

Iranian astronomy was also assimilated by the Arabs at the time of Hārūn, the translations being done by al-Faḍl ibn Nawbakht (d. 815) who was his chief librarian. But Persia seems to have exerted more influence on Arab literature and fine arts than on science and philosophy. Ibn al-Muqaffa'[1] (d. 757), a Zoroastrian convert to Islam, translated *Kalilah wa Dimnah* from Pehlawī (being itself a translation from original Sanskrit). He also wrote a book on ethics and behaviour (*Tahdhīb al-Akhlāq*) based on Indo-Persian sources. From Arabic, *Kalilah wa Dimnah* was, in course of time, translated into practically all the languages of the civilized world and exerted a deep influence on the literature and imagination of a number of modern nations, as witness for

1. *Fihrist*, p. 118.

xample La Fontaine's acknowledging it as a ource of his famous Fables. The original anskrit work in its complete form is stated to e lost.

After Hārūn al-Rashīd's death when al-Mā'mūn succeeded to the Abbasid throne (having defeated his elder brother al-Amīn with the upport of Ṭāhir ibn al-Ḥusayn of Khurāsān nd his Persian mercenaries) he rebuilt Baghdād nd founded his unique Dār al-Ḥikmah where galaxy of expert translators and original nvestigators enriched the Arabic language with the choicest products of Hellenic Science and Philosophy. Foremost among his staff of ranslators was the Nestorian Ḥunayn ibn Isḥāq (809-73), mainly occupied with the translation f Greek works on medicine and philosophy. he scale of remuneration paid to translators n this age of literary supremacy may be gauged rom the fact that Ḥunayn and his collaborators when they were in the service of Ibn Shākir eceived a salary of about £ 250 per mensem, nd when Ḥunayn was appointed Superinten-

dent of al-Mā'mūn's Literary Academy h
received in gold the weight of the books h
transalted.[1] Al-Mutawakkil also extended hi
patronage to Ḥunayn and made him his pr
vate physician and personal friend.

Al-Mā'mūn's zeal for scientific researchre
sulted in the measurement of degree of terres
trial latitude from astronomical observation
conducted on the plain of Sinjār north of th
Euphrates and again in the neighbourhood o
Palmyra. Dr. George Sarton and Philip a
Khouri Hitti state that the length came out a
56½ miles, which is really too small. From
data supplied in al-Khāzinī's *Mīzān-al-Ḥikma*
I obtain this length as roughly equal to 6
miles (assuming the dhirâ' to be equal to 1,6
feet nearly), from the footnote to the Arab
text and translation of al-Bīrūnī's *Kitāb al*
Tafhim by R. Ramsay Wright (Luzac, 1934
p. 120), which is extremely close to the actua
figure. I am not aware of any later Muslim
attempts after al-Mā'mūn's time to repeat th
geodetic survey and am inclined to conclud

1 *Ibn abi Usaybi'ah*, Vol. I, p. 187.

that al-Khāzinī's figures based evidently on al-Bīrūnī's calculations are derived ultimately from al-Mā'mūn's measurements but with a correct estimation of the length of the dhirā'. The matter, however, requires further and more careful investigation.

In al-Mutawakkil's time (847-861) the Ṣābian mathematician Thābit ibn Qurrah (ca. 836-901) and his disciples translated the principal Greek works on geometry and astronomy including the classical treatises of Apollonius of Perga (b. ca. 262 B.C.) and Archimedes (d. 212 B.C.). Latterly Thābit won the personal friendship of al-Mu'taḍid who ruled from 892-902. After Thābit his sons Ibrāhīm and Sinān, his grandsons Thābit and Ibrāhīm and great-grandsons, Abū al-Fārāj (on the authority of *'bn abi Usaybi'ah* and *Qifti*) continued the work of translation and compilation, enriching mathematics and astronomy with their original discoveries and observations. Sinān was the first to embrace Islam and died in 943. His son Ibrāhīm was born in 908 or 909 and died at the early age of 37 or 33; but left an

immortal name in the annals of mathemati through his quadrature of the parabola, t simplest ever made before the introduction the integral calculus.[1]

In the foremost rank of mathematicians all times stands Muḥammad ibn Mūsā Khwārizmī (ca. 780-850). He composed t oldest work on arithmetic and algebra, no unfortunately lost in the original Arabic. Th were the principal source of mathematic knowledge for centuries to come both in t East and the West. The work on arithme first introduced the Hindū numerals to Euro as the very name algorism signifies, and t work on algebra (*Ḥisāb al-Jabr wal-Muqābal* not only gave the name to this impor branch of mathematics in the European wo but contained in addition to the usual analyti solutions of linear and quadratic equatio (without, of course, the conception of imagina quantities) graphical solutions of typical qu ratic equations. It was revised by Abū Kā

1. G. Sarton, *Introduction to the History of Science* (B more), Vol. I, p. 624.

bujaʻ ibn Aslam in the first half of the tenth century. Al-Khwārizmī's *Zij* (consisting of astronomical tables) was also very popular and remained standard until revised by Maslamah al-Majirīṭī (of Madrid) in the second half of the tenth century. These tables included value of trigonometrical sine and tangent functions also, as was the fashion among early writers before trigonometry became a definite subject by itself. He prepared also a map of the earth in collaboration with a number of scientists of al-Mā'mūn's time for his book *Ṣūrat al-Arḍ*.

The greatest of Ṣābian astronomers and one of the most original investigators in Islam, Abū 'Abdullāh Muḥammad ibn Jābir al-Battānī between 877 and 918) was a Muslim scientist well known to the Latin world as Albategnius. On comparing his own observations with those of Ptolemy he discovered the motion of the sun's apogee and the variation of the inclination of the Ecliptic. He arrived at a more correct value for procession of the Equinoxes (54·5" per annum) and initiated the use of sines in trigonometrical calculations. It was from a perusal

of his dissertation on the apparent motion of the fixed stars that Hevilius discovered the secular variation of the moon.

Before him Abū al-'Abbās Muḥammad ibn Kathīr al-Farghānī (Latin Alfraganus, ca. 840) adorned the Dār al-Ḥikmah of al-Mā'mun and took part in the measurements of the degree of terrestrial latitude. His book *Ḥarakāt al-Samāwiyah wa Jawāmi' 'Ilm al-Nujūm*, in which he follows Ptolemy but substitutes more accurate figures based on local observations, enjoyed (in its Latin version known as the *Scientia Stellarum*) great popularity among European scientists of the Middle Ages. Most of Dante's astronomical data were derived from this book. Al-Farghānī built also a nilometer in Fusṭāṭ for al-Mutawakkil.[1] Abū Ma'shar (Latin Albumasar), though better known to Europe as an astrologer, was the first to explain the tides as influenced by the moon (a fact unfortunately ignored by Kepler as savouring of astrology).

1. *Ibn abi Usaybi'dh*, Vol. I, p. 207.

The Arabs were keen students of medicine. Hārūn al-Rashīd was the first Khalīfah to endow a public hospital in Baghdād. The tradition was continued by his successors. Al-Muqtadir appointed Sinān ibn Thābit ibn Qurrah to conduct a regular examination of medical practitioners in Baghdād in 931 and over 800 candidates were thus awarded certificates to practise in their profession. Sinān further instituted travelling hospitals and inspected prisons, administering appropriate treatment to ailing prisoners.[1] As a result of this activity, no less than 34 hospitals were founded in the Muslim world in the course of a few years.

1. *Ibn abi Usaybi'ah*, Vol. I, p. 122.

II

PATRONAGE AT THE EASTERN PROVINCIAL COURTS

WHEN the power of the Abbasid Khalīfahs weakened in the provinces and distant governors began to wield more or less unrestricted authority, scientific inquiry continued unabated under the patronage of local rulers. It was thus that the short-lived Ṭūlūnid dynasty (868-905) acquired credit for the founding of a *bimāristān* in Cairo (in 873) during the rule of Ibn Ṭūlūn. This Ṭūlūnid hospital continued to function till the fifteenth century.

One of the most renowned physicians of the entire world, Abū Bakr Muḥammad ibn Zakariya al-Rāzī (Latin Rhazes) was born in 850 at Rayy near modern Teheran. He received his early training as a pupil of 'Alī ibn Sahl Rabbān al-Ṭabarī (a Jewish convert to Islam), author of *Firdaus al-Ḥikmah*, and himself a great investigator not only in medicine but in

a number of otber sciencės. Al-Rāzī's book, *al-Ḥawī* (Latin *Continens*) was an encyclopaedia of medicine with many extracts from Greek and Hindu authors as well as his own personal observations. While at the court of Manṣūr ibn Isḥāq, the Sāmānid ruler of Fars and Transoxiana, he wrote his *Kitāb al-Manṣūrī* (*Liber Almansoris*), a smaller compilation in ten volumes based largely on Greek medicine. He has contributed largely to Muslim knowledge of gnyaecology, obstetricsand ophthalmology; but the most outstanding work to his credit is his tract on smallpox and measles (*al-Judarī wal-Ḥasbah*),[1] available in English through William A. Greenhill's translation (London, 1848). It is stated to be one of the most accura:e works on these two diseases even from the point of view of modern research. *Liber Almansoris* was published in several editions, one as late as 1890 in Milan.

Al-Rāzī left his mark on surgery also. He was the inventor of the *Seton*. His interest in physics is evident from his investigations onthe

1. Hitti, Footnote, *History of the Arabs*, London, p. 366.

determination of specific gravity by means of the hydrostatic balance, called by him *Mizān al-Tabi'i*; and his book *Kitāb al-Asrār* displays his keenness on chemistry as well, through his descriptionofchemicalprocessesandapparatus. He went over to Baghdād to take up his duties as chief physician and to select a suitable site for a *bimāristān* which he did by hanging up raw meat in various localities and chose the spot where it showed least signs of putrefaction.[1] The *Fihrist* credits Rāzī with the authorship of 113 major and 28 minor works.

Here mention must be made of 'Alī ibn al-'Abbās al-Majūsī's (d. 994) *Kitāb al-Malikī*. He was known to Latin Europe as Haly Abbas and his book as *Liber Regius*, written for the Buwayh Sulṭān 'Aḍud al-Dawlah and less voluminous than al-Rāzī's *al-Ḥāwī*. It remained a standard textbook for a number of years until it was superseded by Ibn Sīnā's world-famous *Al-Qānūn fi al-Ṭibb*. 'Ali ibn al-'Abbās was the first to discuss in a rudimentary man-

1. *Ibn abi Usaybi'ah*, Vol. I, pp. 309-10.

ner the structure and function of the capillaries and to give the right explanation of child-birth, not as was erroneously supposed for ages, as a voluntary effort on the part of the child itself, but as the timely reaction of the muscles of the womb at parturition. Even more illustrious than al-Rāzī's name in the history of medicine is that of 'Alī ibn al-Ḥusayn ibn Sīnā (Latin Avicenna, 980-1037). His all-round knowledge representing all that could be discerned at the time raises him to a position second only to that of Aristotle. For generations to come his word was law. The reverence he enjoyed was due not so much to the absolute correctness of the views he put forward, as it was for his grasp of the subjects he handled and the clarity of his exposition. The title Shaykh al-Ra'īs bestowed on him by his disciples was well merited on account of these rare natural gifts and qualifications.

Young Ibn Sīnā visited Bukhārā to wait on the Sāmānid ruler Nūḥ the second, and having access to the well-equipped royal libraries, engrossed himself in the systematic study of

all that was available. His *Qānūn* in its Latin translation passed through 15 editions in the last 30 years of the fifteenth century.[1] Its pharmacopoeia contained 760 drugs. Ibn Sīnā was the first to detect the contagiousness of phthisis and the spreading of diseases by water. His *Kitāb al-Shifā'* (Latin *Sanatio*), a philosophical encyclopaedia was also very popular. Itcontained much original matter on the theory of music, which in the hands of al-Fārābī led subsequently to far-reaching practical results. Ibn Sīnā was opposed to the then current belief in the transmutation of metals as he considered their differences to be innate and far from superficial. It is a great pleasure to note that the portraits of al-Rāzī and Ibn Sīnā still adorn the great hall of the Faculty of Medicine in the University of Paris.

Ophthalmology was a specially favourite subject of Arab physicians. 'Alī ibn 'Isā's *Tadhkirat al-Kahhālin* treats of 132 diseases of the eye and is one of the earliest Arab treatises on the subject. In the time of al-

1. Hitti, *loc cit*, p. 368.

Ḥākim of Egypt, 'Ammār ibn 'Alī al-Mawṣilī wrote *al-Muntakhab fi 'Ilāj al-'Ayn*. Much valuable work was done on the diseases of the eye and their treatment in the twelfth and thirteenth centuries also, as may be judged from the masterly expositions of Ibn al-Nāqid of Cairo (died in 1188) in his *Kitāb al-Mujarrabāt*, of Khalifah Ibn al-Maḥāsin of Ḥalāb in his *al-Kāfi fi al-Kuḥl* (1256) and of Ṣalāḥ al-Din ibn Yūsuf of Ḥamāh (1296) in his *Nūr al-Uyūn wal-Jāmi' al-Funūn*, which was unsuperseded (it is said) even in the nineteenth century.

The interest roused in astronomy by the school of al-Mā'mūn was carried on to later courts usurping the power of the Abbasid Khalīfahs. The Buwayh Sulṭān Sharaf al-Dawlah built an observatory in his place at Baghdād in 982, where 'Abd al-Raḥmān al-Ṣūfī, Aḥmad al-Ṣāghānī and the celebrated Abū al-Wafā' were engaged on active observational work. 'Abd al-Raḥmān al-Ṣūfī was one of the three greatest practical astronomers of Islam (the two others being Ibn Yūnus and Ulugh

Beg, who will be referred to later). Al-Ṣūfī's illustrated treatise, *Kitāb al-Kawākib al-Thābit al-Muṣawwar* (available in original Arabic, as well as in a French translation by Schjellerup) contains a catalogue of stars based on his own observations, giving their magnitudes and co-ordinates. It is the first star atlas to take cognizance of the nebula in Andromeda and is of great importance even at present, as it has revealed the changes undergone by a number of prominent stars in their magnitudes in the course of ten centuries (for example, theta Eridani), and may throw some light on their proper motions also.

Aḥmad al-Ṣāghānī probably made the astrolabes and other instruments used by himself and other astronomers working in Sharaf al-Dawlah's observatory. Abū al-Wafā' Muḥammad ibn Muḥammad ibn Yaḥyā ibn Ismā'īl ibn al-'Abbās al-Būzjānī (940-998) did valuable astronomical work in Baghdād but this is eclipsed by his researches in pure mathematics. Apart from discussing and solving a number of interesting problems in

pure geometry he contributed considerably to the development of trigonometry, both plane and spherical. He gave a new method of constructing sine tables, the value of sine 30 being correct to the 8th place of decimals (Sarton).[1] A number of European mathematicians have discussed isolated problems handled by Abū al-Wafā', as for example Delambre in *Histoire de l'astronomie an Moyen Age* and H. Suter in the *Encyclopaedia of Islām*, but no extensive text of his has as yet been published.[2]

Among other Muslim mathematicians of this period (a really large number) may be mentioned Abū al-Iṣfahānī, Rustam al-Kūhī and Aḥmad ibn Muḥammad ibn 'Abd al-jalīl al-Sijazī. Al-Iṣfahānī commented on the first five books of Apollonius of Perga's *Conic Sections* and gave a better Arabic edition of the complete work—books 1-7. We may here note in passing that the first four books were translated by Ḥilāl al-Ḥimṣī and the last three by Thābit ibn Qurrah about a century earlier.

1. *Introduction to the History of Science*. Vol. I, p. 667.
2. *Ibid*. p. 667.

Books 5 to 7 are lost completely in the original Greek, and it was from this Arabic translation alone that Abraham Ecchellensis, Professor of Arabic and Syriac in Rome and Paris, and G.A. Borelli published a Latin version of the work in Florence in 1661.[1] Rustam al-Kūhī solved some of the problems of Archimedes and Apollonius that led to equations of a higher degree than the second and discussed the conditions of their solvability—the investigations being among the most brilliant in Muslim geometry.[2] Al-Sijazī made a special study of intersections of conic sections and circles, and replaced the old Kinematical method of trisection of an angle by a purely geometric solution (intersection of a circle by an equilateral hyperbola).

At the court of another Buwayh Sultān Rukn al-Dawlah (932-976) at Kayy, Abū Ja'far al-Khāzin al-Khurāsānī re-determined the inclination of the Ecliptic and solved an old problem from the time of Archimedes that had

1. Sarton, *loc. cit.*, p. 664.
2. *Ibid*, p. 665.

baffled al-Māhānī (died sometime about 874 to 884), *viz*, the division of a sphere by a plane, in a given ratio (in later times known a Māhānī's problem), by solving a cubic equation.

Astronomy was such a favourite recreation with the early Muslims that even private persons with independent means (like the three sons of Mūsā ibn Shakir at Baghdād) installed observatories at their homes. There were astronomers in Shīrāz, Samarqand, Nishāpūr engaged on celestial observations. In yet another independent Sultanate of the Abbasid Khilāfat (that of Ghaznah) we have to record the appearance of an illustrious exponent of the mathematical and physical sciences, Abū Rayḥān Muḥammad Ibn Aḥmad al-Birūni (973-1048), a contemporary of Ibn Sīnā and a distinguished member of the University founded by Sulṭan Maḥmūd at Ghaznah and patronised later by his son and successor Mus'ūd. Al-Bīrūnī wrote his *al-Qānūn al-Mas'ūdī* for this same Sulṭan. It is a treatise on Astronomy and surveys the entire field explored at the time by the Greeks, Persians and Hindūs. He

was a great admirer of the Hindū notation of numerals (including the zero, Arabic *al-ṣifr*) and introduced it along with their newly-discovered system of decimals to the scientific world. His *Āthār al-Bāqiyah fī Qurūn al-Khāliah*, edited by Edward Sachau contains all the details (technical and historical) of all the systems then known and in vogue among various nations for the computation of chronology. Sachau's enthusiasm for the author and Muslim savants in general, leads him to remark that "the fourth century A.H. is the turning point in the history of Islam, and the establishment of the orthodox faith about 500 A.H. sealed the fate of independent research for ever. But for al-Ash'ari and al-Ghazzālī the Arabs might have been a nations of Galileos, Keplers and Newtons".[1]

Al-Bīrūni wrote both in Arabic and Persian. He possibly knew some Hebrew and Syriac, but seems to have been ignorant of Greek. While in India, he studied Sanskrit and had thus direct

1. *The Chronology of Ancient Nations* (Introduction), London, 1879.

access to Hindū mathematics and astronomy. He was a keen observer of Nature and his description of various natural phenomena like the Zodiacal Light (as pointed out by me in Hyderabad Academy Studies No. 2), his correct explanation that the rise of water in springs is due to hydrostatic pressure and his suggestion that the Indus Valley was once an arm of the sea, reveal his remarkable powers of accurate observation and investigation. All this is clearly borne out by his answer to self-imposed questions in his *Kitāb al-Tafhim li-awālī'l Ṣina'at al-Tanjim*. His determination of the specific gravities of various metals, precious stones and minerals as a means of ascertaining their purity and published in al-Khazīnī's *Mizān al-Ḥikmah* presents him in the light of an ardent experimentalist. The values deduced from his tables are remarkably accurate, if we bear in mind the imperfections of the apparatus at his disposal.

With the gradual dismemberment of the Abbasid Khilāfat new dynasties rose to power in different parts of the Islamic world, that

brought down the general level of Muslim supremacy in arms over non-Muslim countries but continued almost unabated the traditions of scientific inquiry and literary output established at Baghdād in its golden prime. Some reference has been made to the scientific activities of the reigns of the Ṭūlūnids, the Sāmānids (874-999), the Buwayhids (945-1055) and the Ghaznawids (962-1186).

III

ENCOURAGEMENT BY THE FĀṬIMIDS

The Buwayhids were ousted by the Saljūqs who continued in power till 1194. These in their turn were overpowered by the Khwārizm Shāhīs, who flourished for a while until their empire was destroyed by Chengis in 1220. Some of the Fāṭimids (909-1171) and the Hamdānids (944-1003) were also great patrons of learning. The court of the Fāṭimid al-Ḥākim in spite of his mental aberrations was destined to become famous through the discoveries and researches of Ibn Yūnus and Ibn al-Haytham. Abu al-Ḥasan 'Alī ibn abī Sa'īd ibn Aḥmad ibn Yūnus(date of birth unknown, died in Qāhirah in 1009) commenced his astronomical observations at about 990 by the order of al-'Aziz at his well-equipped observatory at Cairo. They were completed in 1007 and published under the name of *al-Zij al-Kabir al-Ḥākimi* in honour

of al-Ḥākim. The Zij records observations of eclipses and conjunctions old andnew,improved values of the inclination of the Ecliptic (estimated at 23° 35′), of the longitude of the Sun's apogee (86° 10′) of the solar parallax (reduced from 3′ to 2′), of the procession of the Equinoxes (50″ a year), and makes no reference to the erroneous conception of the trepidation of the Ecliptic (first introduced by Thābit ibn Qurrah and blindly followed by a number of later astronomers even Copernicus, until finally discarded by Tycho Brahe).[1]

Ibn Yūnus' work on trigonometry was less important than Abū al-Fidā's, but as an observer and recorder of astronomical phenomena he was undoubtedly the greatest in Islam.

Abū 'Alī al-Ḥasan ibn al-Ḥasan ibn al-Haytham (Latin, Alhazen) was born in Baṣrah sometime about 965 and died in Cairo in 1039 or so. He was the greatest Muslim physicist and one of the greatest investigators of optics of all times. He was also an astronomer,

1. Sarton, *loc. cit.*, Vol, I. p. 716.

mathematician and physician writingcommentaries of Aristotle and Galen. But his masterpiece was *Kitāb al-Manāẓir*, a treatise on optics, which had a great influence on the training of later scientists of Western Europe (like Roger Bacon and Kepler, etc.). Ibn Haytham's writings reveal his fine development of the experimental faculty. His tables of corresponding angles of incidence and refraction oflightpassing from one medium to another show how closely he had approached discovering the law of constancy of ratio of sines, later attributed to Snell. He accounted correctly for twilight as due to atmospheric refraction, estimating the sun's depression to be 19°belowthehorizon, at the commencement of the phenomenon in the mornings or at its termination in the evenings.[1] (The figure generally accepted nowadays is18°.) He deduced the height of the homogeneous atmosphere on this basis to be somewhere near 55 miles, not at all a bad approximation. He understood the laws of formation of images in spherical and parabolic mirrors, the

1. Sarton, *loc. cit.*, p. 721.

causes of spherical aberrationand ofmagnification produced by lenses.Hegavea much sounder theory of vision than the Greeks, though regarding the lens system of the eye itself to be the sentitive part. (It may be pointed out even at this stage that Ibn Rushd was the first scientist to discover the retina to be the real seat of sensitiveness to light.) Ibn Haytham was able to solve a number of advanced questions also in geometrical optics (for example, the shape of an aplantic surface for reflection), by his good command of mathematics.

IV

WORK IN OTHER DEPARTMENTS OF KNOWLEDGE

HISTORIOGRAPHY AND GEOGRAPHY, ETC.

When the Saljūqs began to dominate over the Abbasid Khalifah (on the downfall of Buwayhids) a fresh impetus was given to the pursuit of astronomical studies. Jalāl al-Din Malik Shāh summoned at his new observatory at Rayy Abū al-Fatḥ 'Omar ibn Ibrāhīm al-Khayyāmī (born ca. 1038 at Nishāpūr, d. 1123-24) to reform the Persian calendar. Khayyām was one of the foremost mathematicians of the Middle Ages (in addition to being a poet of undying fame through his quatrains). His algebra gives an admirable classifications of equation of the second and third degrees. Both analytical and geometrical solutions were explained for the second degree and attempted and partially solved for the third degree. He noted 13

different types of cubic equations and arranged them in the order of their complexity depending on the number of terms involved.[1] (The modern method of classification of equations based on the term of the highest degree in the unknown quantity was introduced only in the sixteenth and seventeenth centuries.) Imaginary roots were, of course, not considered, negative roots too were ignored.

Ulugh Beg's (d. 1449) interpretation of Khayyām's calendar puts in fifteen intercalary days in 62 years with an error of one day in about 3,7 /0 years. Modern interpretation introduces eight intercalary days in 33 years and leads to an error of one day in about 5,000 years.[2] We may add that the Gregorian correction in vogue at present in all civilized countries leads to an error of one day in 3,330 days.

Khayyām worked on the determination of specific gravities also.

At the court of Sulṭān Sanjār flourished 'Abd al-Raḥmān al-Manṣūr al-Khāzinī (about

1. Sarton, *loc. cit.*, p. 760.
2. *Ibid.*, p. 760.

1115-21) a Greek (Rūmī) slave whom his master 'Alī al-Khāzin provided with a good all-round scientific education. His fame rests chiefly on his comprehensive work on the balance, *Mīzān al-Ḥikmah*, published recently with notes, etc., by the Dā'irat al-Ma'ārif of Hyderabad.

Turning now to other mental disciplines of the Arabs, historiography, economics, geography, chemistry, botany, philosophy, etc., it is obvious that only their barest outlines can be sketched here. The Arabs had a natural liking for history and took endless pains to collect historical data and test their accuracy by certain standards that worked all right when applied to their own sources. Most of earlier works were practically statements of events in their chronological sequence but expressed in an elegant style and above all with fair and often impartial criticism. Abū al-Ḥasan 'Alī al-Mas'ūdī (956) was the first to revolutionize the art of writing history. The modern method of dealing with different dynasties or countries or peoples with critical examination of the matter handled may be traced to the same writer.

In the front rank of Muslim histories are reckoned Ibn Isḥāq's (died about 767) *Biography of the Prophet* that has reached us only through a revision by Ibn Hishām (died 834),[1] Mūsā ibn 'Uqbah's (d. 758) *Kitāb al-Maghāzī*, also al-Wāqidī's (died 823) work on the same subject and Ibn Sa'd's (d. 845) *Siyar*, 'Abd al-Ḥakam's (d. 870) *Futūḥ al-Miṣr wa Akhbāruhā* and Aḥmad ibn Yaḥyā al-Baladhurī's (d. 893) *Futūḥ al-Buldān* describe Muslim conquests. The latter's *Ansāb al-Ashraf* deals with the lineages and pedigrees of persons of distinction. Amongst other writers of history may be mentioned Ibn Muqaffa' (d. 757) who translated from Persian into Arabic a history of the Kings of Persia (hence the name *Siyar-i-Mulūk al-'Ajam*, Ibn al-Qutaybah (Muḥammad ibn Muslim al-Dināwarï (d. 889) author of *Kitāb al-Ma'ārif*, Ibn Dā'ūd al-Dināwarī (d. 895) author of *Akhbār al-Ṭiwal*, Ḥāmzah al-Iṣfahānī (d. ca-961) and Ibn Wāḍiḥ al-Yā'qūbī (author of *Kitāb al Buldān*) and Miskawayh (died 1030) author

1. Ibn Khallikān, Vol. I, p. 520.

of a universal history (*Tajārib al-Umam*) from the earliest times down to about 980.

The greatest historian of his century was Abū Ja'far Muḥammad ibn Jarīral-Ṭabarī(838-923) whose monumental work *Akhbār-i-Rasul wal-Mulūk* is a mine of detailed and accurate information. Al-Ṭabarī travelled in Īrān,'Irāq, Syria and Egypt to gather material for his book from original sources, and according to the geographer Yāqūt,[1] wrote40 pages daily for 40 years. Later writers have made free use of this authoritative work. 'Izz al-Dīn ibn al-Athīr's (1160-1234) *al-Kāmil fi al-Tārikh* is an abridged edition ofal-Ṭabarī's older work continued from where it stopped down to 1231. A more original work by Ibn al-Athīr is *Usd al-Ghābah*, a collection of some 7,500 biographies of the Companions of the Prophet. We may mention here Sibṭ ibn al-Jawzī's (1186-1257) universal history from creation to 1256, called *Mir'at al-Zamān fi Tārikh al-Ayyām*.

Reference has already been made to the improved system adopted by al Mas'ūdī in

1. Yāqūt, Vol. VI, p. 424.

writing history. He travelled far and wide in practically every Islamic country in Asia from Baghdād and even went to Zanzibar, settling down finally (in the last decade of his life) in Egypt and Syria, compiling a work of 30 volumes. Only an abridged edition of it entitled *Murūj al-Dhahab wa Ma'ādin al-Jawāhir*, brought down to 947 A.D. has survived. It is not confined to purely chronological facts but gives interesting geographical information as well, besides discussing, wherever appropriate, subjects of non-Muslim history and incipient notions(in vogue at the time) on evolution, *viz.*, successive gradation between inanimate mineral matter, plants, animal and man, in *al-Tanbih wal-Ishrāf*.

Even after the fall of Baghdād there is no scarcity of historians in Islam. They flourished in the petty states that rose on the ruins of the Abbasid Khilāfat. Among this category we find Abū al-Fidā' (1272-1331), author of *Mukhtaṣar Tārikh al-Bashar* (an epitome of Ibn al-Athīr's *al-Kāmil fi al-Tārikh* continued up to his own times), himself of princely rank (a

lineal descendant of a brother of Ṣalāḥ al-Dīn) and Governor of Ḥamāh ; al-Dhahabī (1274-1348) author of *Duwal al-Islām*; Abū al-Maḥāsin ibn Taghrī Birdī (1411-69), attached to the court of Mamlūk Sulṭānsandauthorof*al-Nujūm al-Zāhirah fi Mulūk Miṣr wal-Qāhirah* and Jalāl al-Din Suyūṭi (1445-1505) author of 560 works on theology, history and philology of which we may mention *Ḥusn al-Muḥāḍarah fi Akhbār Miṣr wal-Qāhira, al-Muzhir fi 'Ulūm al-Lughah* and *al-Itqān fi 'Ulūm al-Qur'ān.*[1]

Arab writers excelled equally well in compiling biographies of notable persons. Ibn al-'Asākir's (d. 1777) *al-Tārikh al-Kabīr*, comprising 80 volumes, is devoted to the lives of great men of Damascus. Yāqūt ibn 'Abdullāh al-Ḥamawī (1179-1229) wrote *Mu'jamal-Udabā'*, a charming biography of literati. 'Alī ibn Yūsuf al-Qifṭī (172-1248), author of *Akhbār al-Ulamā' bi Akhbār al-Ḥukamā'*, though a Wazir to Ayyubid rulers, found time to compile biographies of physicians and philosophers; Muwaffaq

1. Hitti, *loc. cit*, p. 668.

al-Dīn Abū al-'Abbās Aḥmad ibn abīUṣaybi'ah (1203-70), himself a physician ofCairo,botanized with the Spanish scientist Ibn al-Bayṭār and compiled a most comprehensive biography of some 400 notable physicians and surgeons (Greek and Arab) in his celebrated work '*Uyūn al-Anba' fi Ṭabaqāt al-Aṭibba'*, an inexhaustible source of information concerning the lives of Arab scientists in general, as the majority of them were not only physicians but astronomers, mathematicians and philosophers as well.

We close this sketchy list with the name of Shams al-Dīn Aḥmad ibn Muḥammad ibn Khallikān (born in Irbil in 1211, died at Damascus in 1281, Qāḍī of Syria and author of a most delightful dictionary of national biograghy, *Wafayāt al-A'yān wa Anba' Abnā' al-Zamān*, dealing with the lives of 868 prominent Musalmans—a marvel of accuracy and elegance.

Search for knowledge, desire for Ḥaj and interest,in trade and innate propensity to see the world and explore its marvels led the Arabs to contribute immensely to geographical science..

They travelled by land and sea to distant China, for example, Ibn Wahb in 870. We read of a Muslim embassy to the Court of the Chinese Emperor Tai-Tsung in 628 (three years before the Nestorian missionaries) by sea to Canton in a trading vessel from Yanbū', the port of Madīnah, and building a mosque there for the Arab traders. An unknown author has written (in 851) an account of a certain merchant Sulaymān who roamed about the Far East. It is from this account that the civilized world first came to know of the topography and physical features of the East Indies. The practice of thumb-impression as a means of identification in China was made known by Sulaymān to the Arabs. The first authentic account about Russia was published by Aḥmad ibn Faḍlān ibn Ḥammād who was deputed by Khalīfah al-Muqtadir in 921 to the court of the King of Bulgarians on the River Volga.[1] Abū Zaid al-Balkhī set the example of writing systematic account of countries under the Muslim sway when he was at the court of a

1. Sarton, *loc. cit.*, p. 636.

Sāmānid prince. This work is lost, but al-Iṣtakhrī's (flourished in 950) elaborate *Masālik wal Mamālik* that has come down to us with coloured maps of countries and other details is said to be based on it.[1]

Al-Mas'ūdī's history is rich in geographical details also. He is the first to mention windmills in Sijistān and writes about Muslim traders actively engaged in business in Bohemia. Ibn Ḥawqal (943-77) revised later al-Iṣṭakhri's book after travelling as far as Spain to gain first-hand knowledge. Al-Muqaddasī (or Maqdisī) who visited all the Islamic countries except Spain, Sijistān and India during an itinerary of twenty years, wrote (in 985 or 986) an account of his experiences in his delightful book *Aḥsan al-Taqsīm fi Ma'rifat al-Aqalīm*.

It is appropriate to speak in this connection of Ibn Khurdādhbih's (d. 912) first publication (near about 846) of the useful series of road books, which he had issued as the Director of the Post and Intelligence Department in

1. Hitti, *loc. cit.*, p. 385.

al-Jibāl. Ibn Waḍīḥ al-Ya'qūbī's *Kitāb al-Buldān* which appeared in 891 or 892 contained in addition to ordinary geographical matter useful information on economical and other topies. Qudāmah, a Christian by birth, and appointed Revenue Accountant in Baghdād after 928, became a convert to Islam and discussed in his book *Al-Kharāj* the various provinces of the Abbasid Khilāfat, its system of taxation and postal service. Al-Ḥasan ibn Aḥmad al-Hamadānī (who died in prison in San'ā 945) deserves special mention on account of his books *Al-Iklil* and *Jazīrat al-'Arab*, which contain valuable information on pre-Islamic and Islamic Arabia. The *Rasā'il-i-Ikhwān al-Ṣafā'*, a series of papers issued by a secret society in Persia about 970 A.D., among other interesting matters boldly surmises large-scale climatic changes to be taking place on the earth in course of ages, fertile lands passing into deserts, the sea encroaching on land and the land rising out of sea.

By far the most comprehensive writer of geography during the closing years of the

Abbasid period was Yāqūt (whose *Mu'jam al-Udabā'* was referred to in biographies). He was a Greek boy purchased by a merchant of Ḥamāh and given liberal education. For a number of years he accompanied his master as his commercial clerk and wes later enfranchised. He then took to copying and selling manuscripts and travelled extensively in the pursuit of this profession, collecting valuable material for his encyclopædic geographical dictionary, *Mu'jam al-Buldān*, commenced at Mawṣīl in 1224 and completed at Ḥalab in 1228, where he died. It is a veritable storehouse of geographical knowledge of the time containing useful information on ethnography and natural science as well.

We have to speak of Abū al-Fidā' also in the list of prominent geographers. Though engaged in wars ever since he was 12 years old his zeal for science and powers of observation enabled him to incorporate in his work on history important geographical matter, like the latitude and longitude of a number of cities, deduced mostly from his own observations. It

may be remarked in passing that longitudes were reckoned in those days (following Pliny) from the Canary Islands.

Aḥmad al-Qalqashandī (d. 1418) who held important posts under the Mamlūk Sulṭāns of Egypt was author of *Ṣubḥ al-A'sha* and gives useful geographical information in that work.

The Arabs made free use of the magnetic compass and the stars to help them navigate their ships on the high seas. They may not have been the first to observe the directive properties of the compass needle but they certainly anticipated the Chinese in its use in navigation. Aḥmad ibn Mājid of Najd, who is generally credited with having piloted Vasco da Gama's ship from Africa to India in 1497, wrote a book called *Al-Fawā'id fi Uṣūl al-Baḥr wal-Qawā'id* which has been edited by G. Ferrand in Paris in 1921-23.[1] It may be noted here that Aḥmad ibn Mājid styled himself as the fourth Sea-lion (for skill in navigation), the other three being

1. Hitti, *loc. cit.*, p. 689.

Muḥammad ibn Shādhān, Sahl ibn Abān and Laith ibn Kahlān, that probably flourished in the first half of the twelfth century.[1] In all probability, the Arabs initiated also the use of charts to steer their ships into the sea-ports they frequented, long before the Venetians and Genoese prepared their portalani. For trade reasons they must have kept these secrets for a long time.

1. Sarton, *loc. cit.*, Vol. II. p. 221.

V

"BELLES-LETTERS," RELIGIOUS LITERATURE AND PHILOSOPHY

In this brief sketch it is impossible to do more than just mention a few outstanding works on Arabic literature (sacred and secular). Abū al-Aswad al-Du'alī who flourished at Baṣrah and died there probably in 688 or 689, Hijrī year, aged 85, is generally considered to be the discoverer of Arabic grammar (*Ibn Khallikān*, Vol. I, p. 663). Khalil ibn Aḥmad (born in 'Omān ca. 717, died in Baṣrah in 791 or 792) is generally regarded as the founder of Arabic prosody. He certainly systematized its grammar and wrote unfinished lexicon called *Kitāb al-'Ayn* His Persian pupil, Sībawayh (d. ca. 793) composed the first basic text-book on Arabic grammar called *al-Kitāb*. Later, Jamāl al-Dīn Abū 'Amr 'Uthmān ibn 'Umar ibn al-Ḥājib (1175-1249) wrote in addition to his *al-Kafyah* and *al-Shawyah* (concise

works on Arabic grammar) *Kitāb al-Maqṣad al-Jalīl fī 'Ilm al-Khalīl*, on the subject of Prosody.[1]

More famous than either of the above two names is that of Abū al-Qāsim Muḥammad ibn 'Umar al-Zamakhsharī (1075-1144) called Jār-Allāh for having lived in Mecca for a long time. His grammar *Kitāb al-Mufaṣṣal* and lexicon *Kitāb Muqaddimat al-Adab* (Arabic-Persian) are still considered standard works.[2] Mention may also be made of 'Abd al-Raḥmān al-'Anbārī's history of Arabic literature and philology entitled *Kitāb al-Nuzhat al-Aṭibbā' fi Ṭabaqāt al-Udabā.*' He was a lecturer at the famous Niẓāmiyah of Baghdād. So was Shaykh Abū al-Farj ibn al-Jawzī, an encyclopaedic writer on many branches of learning, including *al-Muntaẓam.* Poetry kept up its hold on the Arab mind in all countries and climes. Many poets preferred the Jāhiliyah style but Persian influence somewhat modified this tendency. It is no exaggeration to say

1. Sarton, *loc. cit.*, Vol. II, p. 700.
2. Ibid., Vol. II, p. 271.

that almost every educated Arab (both in the East and the West) indulged in versification. Among poets of later times may be mentioned al-Mutanabbī (915-65), laureate at the court of Sayf al-Dawlah Hamadānī, whose ornate and flowery style made him one of the most popular and widely-quoted Arab poets of all times. Among notable prose writers (whose list will require a lifetime to prepare) a few prominent ones have already been noticed (*e.g.*, the authors of *al-Aghānī* and *al-Fihrist*, etc.) while discussing works on history, biography and geography. For excellence of style (though somewhat effected) Badī al-Zamānal-Hamadhāni (969-1008), and, after him, al-Ḥarīrī (1054-1122), author of the famous *Maqāmāt*, are generally considered unrivalled. No account of Arab literature will be considered satisfactory without a reference to the tales of *Alif Laylah wa Laylah* that centre round the court of Hārūn al-RashīdatBaghdād and of the Mamlūk Sulṭāns at Cairo. They are supposed to have been told by different authors at different times and to be based on

works of Persian origin.

To attempt a discussion of religious literature published in Arabic will take us far away from our prescribed course even if we considered ourselves competent for the task. Even a cursory acquaintance with thestandardworks on *Ḥādīth* and *Fiqh* and a knowledge of the great pains taken to collect and verify the former and systematize the latter will show how solidly and judiciously the Muslim *Sharī'at* is built. It is really marvellous how the early Muslim scholars of Tradition (*Muḥaddithīn*) and theological jurists performed their self-imposed duties unmoved by opposition and undaunted by authority. No wonder that Muḥammad ibn Ismā'īl al-Bukhārī (810-70), Muslim ibn al-Ḥajjāj (d. 875), Abū Dā'ūd (d. 888), al-Tirmidhī (d. ca. 892), Ibn Mājah (d. 886) and al-Nasā'ī, the authors of the six canonical works on *Ḥadīth*, are still held in great veneration ; and that about 30 million Muslims are technical adherents of the school of Mālik ibn Anas (715-95); 118 million adherents of al-Nu'mān ibn Thābit, Abū Ḥanīfah (d.

767); 73 millions of Muḥammad ibn Idrīs al-Shāfi'ī (d. 820) and 3 millions of Aḥmad ibn Ḥanbal (d. 855).[1]

There were a number of Muslim philosophers both in the East and in the West. They did not fell the necessity of propounding new hypotheses of forming novel schools of thought. All the great philosophers of Islam were sincere Muslims. Whenever they thought there was some apparent lack of harmony between the teachings of revealed religion and discoveries of science they tried to reconcile the two as both were regarded as correct. This process came to be known as scholasticism in the best sense of the word. Foremost among such Eastern Muslim philosophers were al-Kindī, al-Fārābi, Ibn Sīnā' and al-Ghazzālī. We shall mention a few facts about the lives and works of each of them.

Abū Yūsuf Yā'qūb ibnIsḥāq al-Kindīwasof

1. We gratefully acknowledge that these figures and the majority of dates given in this memoir are taken from P. K. Hitti's *History of the Arabs* (London, 1937).

pure Arab extraction, bornatKūfain the middle of the ninth century and flourishedatBaghdād. He was an all-round scientist in addition to being a great philosopher of the school ofAristotle. In Neo-Platonic spirit he aimed atreconciling Aristotelian views with Platonic ideas. His best and most popular work was his *Optics* which in its Latin translation was used as text-book in the Westfor a number of years until replaced by Ibn al-Haytham's more complete work later. He was author of over 250 works on different subjects : philosophy, alchemy, astrology, theory of music, etc., some of which are extant only in their Latin versions, others being completely lost—the common lot unfortunately of most Arabic works published before the Tartar invasions. Al-Kindī gives full significance to rhythm (Arabic *Iqā'*) as an important constituent of Arabic music, showing thereby that mensural music was known to the Arabs centuries before the Christian peoples of Europe.

Muḥammad ibn Muḥammad ibn Tarkhān Abū Naṣr al-Fārābī (Latin, Alpharabius) was a

Turk born in Transoxiana, near about 870, and flourished at the court of Sayf al-Dawlah al-Hamadānī. He died at Baghdād in 950. Besides being a first-rate philosopher he was an expert in both the theory and practice of music. His commentaries on Aristotle, Plato and other Greek philosophers reveal his belief in the reconcilability of Aristotelianism with Platonism through the medium of Ṣūfism. Among his books are *Risālah Fuṣūṣ al-Ḥikam*, *Risālah fī Ārā' Ahl al-Māḍinah al-Fāḍilah* and *Siyāsat al-Madaniyah*, the last two being based on the ideas of Plato's *Republic* and Aristotle's *Politics*. His work on music, *Kitāb al-Mūsiqī al-Kabīr* presents him in the light of a great practical authority on this subject. He played exquisite music on the lute (Arabic *al-'ūd*) and could move the entire court of Sayf al-Dawlah to roaring laughter or to tears according to the character of the tunes he played.

Ibn Sīnā's work as a physician has already been dealt with in connection with the development of Arab medicine. His philosophy is

embodied (along with other matter) in his encyclopa dic treatise *Kitāb al-Shifā'* (Sanatio). It may be taken to represent Aristotelian traditions modified by Neo-Platonic ideas and at the same time kept in control by Muslim theology. He died at a comparatively early age (57 years) but left a permanent impression on all the intellectual disciplines of the Middle Ages: physics, mathematics, metaphysics, ethics, economics, politics, logic, psychology and music. He was keen on experimental work also, to which his investigations on specific gravity and the design of a simple device similar to that of the modern Vernier (for increase in accuracy of length measurement) bear ample testimony.[1]

Such abstract physical subjects as the nature of motion, of contact, force, vacuum, infinity, light and heat, were also tackled by him, and his powerful intellect, in spite of the paucity of correct data available in those days of early science, could lead him to sound conclusions, as for instance the finite velocity of light and the impossibility of chemical trans-

1. Sarton, *loc. cit.*, Vol. I, p. 710.

mutations. He was probably the most comprehensive and clear-headed scientist of Islam and certainly one of the most famous of all nationalities, places and times.

Abū Ḥāmid al-Ghazzālī, born in 1058 at Ṭūs where he died in 1111, was one of the noblest men of all times and the greatest theologian of Islam. He fixed the ultimate form of the Ash'arīya system founded by Abū al-Ḥasan 'Alī al-Ash'arī (d. 935-6) of Baghdād (*viz.*, tacit belief in religious dogmas outside the reach of worldly comprehension). Al-Ghazzālī's mental struggles to reconcile the tenets of Islam with the teachings of prevailing philosophy and science are recorded in his own words. He was at one time a professor at the Niẓāmiyah at Baghdād, then turned a sceptic for a while, wandering about for twelve years in search of truth and mental peace, and finally found solace in Ṣūfism. His masterpiece, *Iḥyā' 'Ulūm al-Dīn* and other similar works were widely read by Muslims, Jews and Christians, and contributed to the spread of scholasticism in Asia and Europe, as may be

judged by their influence on Thomas Aquinas and even Blaise Pascal. Some European critics attribute to his (and al-Ash'arī's) teachings the decline noticed in the prosecution of scientific studies among Muslims from the twelfth century onwards. But this seems to be too sweeping a remark. There were many more potent factors that brought a bout this decline and al-Ghazzālī was himself a great advocate of seeking after truth in matters both spiritual and temporal.

VI

EARLY ARAB NOTIONS OF CHEMISTRY, BIOLOGY AND ALLIED SCIENCES

Chemistry is generally supposed to be an accidental product of alchemy, but it would be a fairer appreciation of human intellect to say that early misconception of chemical phenomena by adventurous man tempted him, after his acquaintance with the glamour of gold and precious stones, to dabble in alchemy, just as his early attempts to understand the movements of the heavenly bodies misguided him to believe in astrology. Centuries of bitter experience and disappointments directed him into the right tracks, and the results of prolonged observations and experiments ultimately led him to build up the modern sciences of astronomy and chemistry. Before the advent of the Arabs on the intellectual scene, man knew the main properties of the metals he employed and the preparation of their simpler

mad al-Ḥāsib (or Kātib) compiled a work *Manāfi' al-Ahjar*[1] dealing with the properties of certain minerals. A much better compilation entitled *Azhār al-Afkār fi Jawāhir al-Ahjar* by Shahāb al-Dīn al-Tīfāshī (who died in Cairo in 1253) discusses the properties (medicinal and 'Magical'), purity, price, place of origin, etc., of 24 precious stones.

Biology in its modern sense had to wait till the invention of microscopes of high power, but rudimentry notions concerning the habitat, behaviour, and classification of animals and plants were eagerly acquired and recorded by the Arabs even from the Umayyad days. Their interest in the breeding of horses and camels was responsible for some early works of this kind. 'Abd al-Malik ibn al-Quraib al-Aṣma'ī, a very pious Arab of Baṣrah (739-83) besides being a good student of Arabic poetry wrote *Kitāb al-Ibil, Kitāb al-Khail, Kitāb al-Wuḥūsh, Kitāb al-Shā'* and *Kitāb Khalq al-Insān*, the last mentioned work revealing a considerable

1. *Fihrist*, p. 278.

knowledge of human anatomy.[1]

Al-Naẓẓām (d. ca. 845), a leader of the Mu'tazilite school, that believed in the creation of the Qur'ān, propounded a theory of evolution, according to which Adam and all his descendants though created by God at one and the same time were in a state of Kumūn and appeared in succession at their appointed times in accordance with a preordained plan.[2] His pupil 'Uthmān 'Amr ibn Baḥr al-Jāḥiẓ (d. 868-69) of Baṣrah wrote a book on animals called *Kitāb al-Ḥayawān*, but its treatment savoured more of theology and folklore than strict biology. Nevertheless it refers to the struggle of animals for existence and their adaptation to environment.[3] Al-Jawāliqī who flourished in the first half of the twelfth century and 'Abd al-Mu'min who flourished in the second half of the thirteenth century in Egypt, also wrote books on horses. The greatest 'Zoologist' among the Arabs was al-Damīrī (1405) of

1. Sarton, *loc. cit.*, Vol. I, p. 534.
2. *Ibid.*, p. 550.
3. *Ibid.*, p. 597.

Egypt whose book on animal life, *Ḥayāṭ al-Ḥayawān* has been translated into English by A.S.G. Jayakar (London, 1906, 1908).[1]

More scientific work was done by the Arabs in Botany. Use of plants and their products in medicine primarily induced them to attend to this subject. Muwaffaq al-Dīn Shams al-Riyāṣa Ibn Jamī' (died 1193), an Egyptian Jew, and physician to Ṣalāḥ al-Dīn, wrote on lemons and rhubarb and their uses.[2] In dealing with Spanish Islam we shall refer to the herborization of Muslim scientists of Spain. Among Eastern Muslims we may mention Ibnal-Ṣūrī al-Dimashqī's deliberate search for plants in the country surrounding Damascus and the mountains of Lebanon, where he studied them at different stages of their growth, in the first half of the thirteenth century.

Much valuable information may be gleaned from the writings of al-Bīrūnī and Ibn Sīnā on physical geography and rudiments of geology.

1. Hitti, *loc. cit.*, p. 382.
2. Sarton, *loc. cit.*, Vol. II, p. 432.

Al-Bīrūnī's correct explanation of rise of water in springs and his suggestion concerning the origin of the Indus Valley have already been referred to. He was also the first to observe a fixed number of petals in flowers 3, 4, 5, 6 or 18, never 7 or 9.[1] Al-Dīnawarī also wrote a book on plants. Ibn Sīnā's view on the formation of mountains are interesting. His treatise on minerals was the main source of knowledge on this subject for generations.[2]

1. Sarton, *loc. cit.*, p. 708.
2. *Ibid.*, pp. 710-11.

VII

MECHANICAL CONTRIVANCES AND MILITARY SCIENCE

The Arabs and their immediate Muslim successors to the mastery of the civilized world do not seem to have added very much to the engineering sciences they learned from the Greeks, though in mechanics they certainly improved the theory and performance of the hydrostatic balance, the usefulness of the Alexandrian hydrometer and the efficiency of the Syrian water-wheels. Cheap slave labour with its ease and comfort, its human association and pompous display may possibly have prevented them from exploiting the forces of nature and tapping hidden sources of mechanical and thermal energy which modern nations under harsher conditions of life find indispensable for their very existence. Locomotion by land or sea could be satisfactorily maintained by the friendly horse or camel and the familiar.

sailing vessel.

Al-Khāzinī's (Abū al-Fatḥ'Abd al-Raḥmān al-Manṣūr, astronomer at the court of Saljūq Sulṭān Sanjar ibn Malik Shah) *Mizān al-Ḥikmah* (The Balance of Wisdom) is a masterly dissertation of mechanics as far as it was developed up to that time, *viz.*, 1121 or 1122 A.D. It deals with the theory of the balance from an application of the Theorem of Moments and discusses the buoyancy of liquids (and of air also). It gives a table of weights in water of a number of metals and minerals weighing 100 mithqāls in air (leading to remarkably good values of specific gravities), along with a correct explanation of the weights of material bodies as caused by a universal pull towards the centre of the universe (meaning thereby the earth's centre), and seemingly concentrated at a definite point in each body (its centre of gravity); and remarks in a general way on the weight of the atmosphere.

It is full of important experimental details and shrewdly recognises the effects of surface

tension in liquids. There are references in the book to the construction and use of the immersion hydrometer for determining the densities of liquids (with appreciation of their variation with change of temperature); also to geodesy and levelling and to the measurement of time. The work has been ably described and commented upon by N. Khanikoff in the *Journal of the American Oriental Society* (Vol. VI, pp. 1-128, New Haven, 1859), and has been recently published in original by the Da'irat al-Ma'ārif, Hyderabad Deccan, with a note by the present writer.

Befor the rise of capitalism trade, however extensive, was mostly the enterprise of individuals or families, and seems to have been undertaken as much for the adventure of meeting new peo les in new countries as for making large profits. Under such circumstances there is *little* wonder that applied mechanics and engineering remained practically where Greek intellect had left them. The Arabs, however, made better and more accurate devices for measuring time, clepsydras or water-clocks.

The earliest reference to a clock is found in al-Jāḥiẓ's *Kitāb al-Hayawān* in the second half of the ninth century.[1]

Between 1146 and 1169 Muḥammad ibn 'Alī ibn Rustam al-Khurāsānī al-Sā'ātī constructed the clock placed on the Bāb al-Jayrūn of Damascus (hence Bāb al-Sā'ah, by which name it was often called). Muḥammad ibn 'Alī remained in charge of the clock till his death in 1184 or 1185. It was seen and mentioned by Ibn Jubayr, Qazwīnī, Ibn Buṭṭūṭah and others. Muḥammad ibn 'Alī's son, Fakhr al-Dīn Riḍwān (ibn al-Sā'ātī) repaired and improved this clock and in 1203 wrote a book explaining its use and construction. Riḍwān was born in Damascus and entered the service of the Ayyūbid princes al-Fā'iz Ibrāhīm and Mu'aẓẓam 'Isā, sons of al-'Ādil Sayf al-Din, ruler of Egypt and Syria from 1198 to 1218.

[It may be remarked here that al-'Ādil and his sons were great patrons of learning. Muhadhdhib al-Dīn Abū Muḥammad 'Abd al-

1. Sarton, *loc. cit.*, Vol. II, p. 632.

Raḥīm ibn 'Alī al-Dimishqī, teacher of the famous writer Ibn Abī Uṣaybi'ah and the great physician Ibn al-Nafīs 'Alā'-al-Dīn Abū al-Ḥasan held important medical posts under these potentates. Ibn al-Nafīs, it may be noted, is regarded by modern Egyptian physicians to have anticipated William Harvey in the correct explanation of the circulation of the blood.][1]

An important treatise on mechanical sciences, *Kitāb al-Ma'rifat al-Hiyal al-Handasah* (dealing chiefly with hydraulic appliances, now available in a German translation with commentaries by Eilhard Wiedemann) was composed by Abū al-'Izz Ismā'īl ibn Razzāz Badi'al-Zamān al-Jazarī at Āmid in Diyār Bakr for the Urtaqid ruler Nāṣir al-Dīn Muḥammad, probably in 1205 or 1206. A critical study of the original Arabic will doubtless throw much light on Arab technique of time-measurement.[2]

With regard to military science, Najm al-Dīn al-Aḥdab Ḥasan al-Rammāh, a Syrian,

1. Sarton, *loc. cit* , p. 1009.
2. *Ibid*., pp. 631-32.

wrote shortly before 1300 a treatise called *al-Furusiyah wal-Manāsib al-Ḥarbiyah*, which describes the purification of nitre (possibly as an ingredient for manufacture of gunpowder) and contains pyrotechnic recipes. The earliest reference to the use of gunpowder is in al-'Umarī (d. 1348).[1] Egyptian physicians called it *Talj al-Sīnī* (Chinese snow), probably only its constituent nitre being meant.[2]

1. Hitti, *loc. cit.*, p. 665
2. Sarton, *loc. cit.*, Vol. II, p. 1036.

VIII

FALL OF BAGHDĀD AND MONGOL RESPONSE TO ISLAM

Changiz Khān's destruction of Samarqand, Bokhārā and Balkh, and in fact of the entire Khwārizm Shāhī Empire in 1220 was followed by Hulāgū's invasion of the tottering Abbasid Khilāfat, already dismembered into petty semi-independent states in the east and west. Fanatics and Crusaders were harassing the Fertile Crescent at about the same time and the final crash came when in 1258 the Tartar hordes under Hulāgū sacked Baghdād and levelled to the dust its palaces and public buildings, putting to the sword practically every member of al-Musta'ṣim's family and looting and burning the invaluable treasures of fine arts and learning that his illustrious predecessors had collected so laboriously for generations in the proud capital of their vast empire. The full significance of the havoc thus wrought can

be better imagined than described.[1] A sober estimate would have us believe that only one book out of every thousand listed in Ibn al-Nadīm's *Fihrist* escaped destruction. The fall of Baghdād was not only a death-blow to Muslim culture, it was (in its ultimate effects) an immense set-back to word civilization in general. Sa'di's (1184-1283) lament over this terrible calamity in a poem of about 25 verses will for ever keep its memory alive in the hearts of students of Persian literature.

Had it not been for the heroic resistance or the Mamlūk Sulṭāns of Egypt (Baybars and Qala'ūn) culminating in their complete victory at 'Ayn Jālūt in 1260 and at Ḥims in 1280, the whole Muslim world would have been trampled under the feet of the Tartar savages. (The Mamlūks later expelled the Crusaders also from ever city they had formerly captured.)[2] The culture and religion of Islam, however, eventually triumphed over the brute forces of the Tartars, and we find a new centre of cultural and scientific activity growing at

1. Fakhri, p. 454.
2. Ibn al-'ibri, p. 500.

Marāghah (and later at Samarqand under the patronage of these very Tartars (or of their Muslim descendants), but this renaissance was shortlived and was negligible compared to past achievements.

At Marāghah an observatory was built the very next year after the fall of Baghdād under the supervision of Naṣır al-Dın Ṭūsī and he and his colleagues again lighted the lamp of learning. It is impossible to overestimate the importance of Naṣīr al-Dīn's contributions to mathematics.

Abū Ja'far Muḥammad ibn al-Ḥasan, Naṣīr al-Dīn al-Ṭūsī surnamed al-Muḥaqqiq, was born in 1201 and was kidnapped at an early age by the Ismā'īlī governor of Qūhistān. He was kept under watch at the Ismā'īlī stronghold of Alāmūt till the Mongols captured it. He entered Hulāgū's service and rose to the rank of Wazīr through his talents and died in Baghdād in 1274. He may have known some Greek but certainly knew the Greek mathematicians and their classical works through Arabic translations, and edited a large

collection of Arabic works on the standard Greek geometers and astronomers in his *Kitāb al-Mutawassiṭat bain al-Hindasah wal-Hai'a.* His fame as a great mathematician rests primarily on his work on trigonometry. But his achievements in other branches of mathematics are also highly commendable. His discussions of Euclid's axioms and postulates are masterly and laid the foundations of non-Euclidean geometry. His treatise referring to Menelaus' theorem, entitled *Shak al-Qatta'* (known to Medieval Latin Europe under the name *Figura ata*) is divided into five books of which books third and fourth deal with plane and spherical trigonometry respectively, the earlier books dealing with transversals, etc. He did much original work in these subjects and deduced some elegant theorems on roulettes also.[1]

At the Marāghah observatory a number of efficientand newely-designed instruments were used for making observations on stars, etc., by Naṣīr al-Dīn and his staff, hence the excellence

1. Sarton, *loc. cit.*, Vol. II, Part II, pp. 1001-7.

of the astronomical tables prepared there—
Zīj Ilkhānī. Naṣīr al-Dīn received his ma
training from his teacher Kamāl al-Dīn i
Yūnus and before going over to Marāghah h
probably written his *Tadhkirah fi 'Ilm al-Hai*
a very condensed textbook of astronomy. H
criticism of Ptolemy's *Almagest* regarding t
theory of planetary motion paved the way f
the introduction of the Copernican system.

Naṣīral-Dīn'smostbrilliantpupil,Qutb a
Dīn Shirāzī(1236-1311), wrote *Nihāyat al-Idrā*
fi Dirāyat al-Aflāk, which is largely a develo
ment of the *Tadhkirah* in astronomical topic
but also contains valuable discussions o
geometricaloptics, likethe nature of vision an
the formation of the rainbow. The primar
bow is explained as due to two refractions an
one internal reflections and the secondary t
two refractions and two internal reflections
solar rays in minute spherical drops of wate
suspended in the air—essentially the same a
that given by Descartes in the sixteenth cen
tury. Of course the colours of the rainbow ha
to wait till Newton's experiments on th

dispersion of light for their correct interpretation.

Qutb al-Din travelled extensively in the countries of Eastern Islam, and on entering the service of the Īlkhān of Persia, Aḥmad, was sent by him on an embassy to Sayf al-Dīn Qala'ūn, Mamlūk Sulṭan of Egypt, to inform him of his (Aḥmad's) having embraced Islam and to conclude a treaty of peace.[1]

Kamāl al-Dīn Fārisī (died ca. 1320) was a famous pupil of Qutb and under his inspiration wrote *Tanqih al-Manāẓir* (a commentary on Ibn al-Haytham's classical work on optics, *Kitāb al-Manāzir*) which has recently been published with notes, by the Dā'irat al-Ma'ārif, Hyderabad.

Muslim Mongol interest in astronomy manifested itself again in the institution of an observatory at Samarqand under the patronage of Ulugh Beg (1393-1440), a grandson of Tamerlane who published a catalogue of stars comparing his own observations of their magnitudes, etc., with those of Ptolemy and

[1] Sarton, *loc. cit.*, Vol. II, p. 1017.

al-Ṣūfī, along with planetary tables. Ulu
Beg was assassinated by his eldest son throu
jealousy for preference shown to the secon
After his death astronomy ceased altogeth
to be a subject of inquiry at Samarqand.

IX

ARAB ENTERPRISE IN IFRIQYIYAH, SIQILLIYAH AND ANDALUSIA, ETC.

Arab conquest of North Africa began after
qbah ibn Nāfi' built al-Qayrawān in 670, at
site of old Carthage. Hārūn al-Rashīd
ointed Ibrāhīm ibn al-Aghlab governor of
nis in 800, and he ruled the country as an
lependent Amīr till 811, with Qayrawān as
ital. It served as a base of operation
inst the Byzantine colonies round the
diterranean, and Sicily was conquered in
.[1] The Aghlabid dynasty lasted till 909 and
that time converted the Latin-speaking
ristians of North Africa into Arabic-speak-
Muslims by the usual methods of conces-
ns and amelioration. Muslim rule in Sicily,
h Balarm (Palermo) as capital was at its
ght during the reign of Abū al-Futūḥ Yūsuf
'Abd Allāh (989-98) and lasted for 189
rs (after Ibrāhīm's death in 902) until 1091,

1. Ibn al-Athīr, Vol. VIII.

when it was completely appointed by th
Normans.

Even after their subjugation by the Nc
mans, the Arabs of Sicily and Western Islam
general continued to be the leaders of cultu
and erudition in that island. Roger II and h
grandson Frederick II of Hohenstaufen (rule
of Sicily and Germany, Emperor of the Ho
Roman Empire after 1220, and King of Jeru
salem, 1225) favoured the Arabs and encoura
ed them to found a colony of their own at Gir
enti (moved later to Lucera). It was at the cou
of Roger II that Abū 'Abdullāh Muḥammad ib
Muḥammad at-Idrīsī (born at Ceuta in 1100 d
Hispano-Arąb parents and died in 1166) wro
his treatise on geography and cartograph
(*Kitāb Rujar*), entitled *Nuzhat al.Mushtāq*
Ikhtirāq al-Āfāq. It is a monumental wor
combining with the main information availabl
from Ptolemy and Mas'udī's treatises muc
original matter collected by Idrīsī himself fro
reports of observers that were sent to variou
countries to acquire data. He presented t
Roger II a celestial sphere and disk-shape

nap of the world, both made of silver.

We shall discuss later the importance of this lorman patronage of Arab learning to Europ- an civilization. Another great name will now e introduced that has made distant Morocco amous in the annals of mathematics and astro- omy. Abū 'Alī al-Ḥasan ibn 'Alī ibn 'Umar l-Marrākushī (died 1262) died most of his work n Morocco. His book, *Jāmi'al-Mahādi wal- hayat*, is a very comprehensive work on astro- omy (practical as well as theoretical), with escription of instruments and chapters on igonometry containing tables not only of nes (for ever half degree of angle) but of ersed sines (Arabic Sahm, singular), arc sines nd arc co-tangents. He makes free use of gra- hical methods also in the solution of problems. here is a catalogue of 240 stars for the year 22 A.H. (1225-26). Latitudes and longitudes of 35 places are also given, of which he himself bserved 34. He gives the value of the Preces- on of the Equinoxes as 54″ perannum.[2] In

1. Hitti, *loc. cit.*, p. 609.
2. Sarton, *loc. cit.*, Vol. II, Part II, pp. 621-22.

pure literature also we find a most popul
contribution from North Africa; the poem
al-Burdah by Sharaf al-Dīn Muḥammad a
Būṣīrī (1213—ca. 1296), inspired by his gra
tude and devotion to the Prophet for
miraculous cure. It has been translated int
Persian, Turkish, German, French, Englis
and Italian, with some 90 commentaries on
in various languages.[1]

Turning now to Spain, we may note tha
Arab intellectual activity in that country reall
begins with the advent of 'Abd al-Raḥmān (a
Dākhil) ibn al-Mu'āwiyah, a grandson o
Hishām, tenth Umayyad Khalifa of Damascu
in 755, after civil wars among the Arab leade
that had settled in that country. There was, o
course, a surprising amount of preparatory wo
done in the earlier stages, since Ṭāriq ibn Ziyā
routed Roderick at the mouth of the Barba
river, but it was chiefly the conquest of an alie
country under an incessant urge to mov
forward. 'Abd al-Raḥmān II (al-Awsaṭ) whil
supporting religion at his court, through Yaḥy
ibn Yaḥyā, a pupil of the famous Mālik ib

1. Hitti, *loc. cit*, p. 689.

Anas, encouraged the fine arts also with the same zeal. He welcomed to his court Ziryāb, one of the greatest singers and musicians of his time, when he fled from Baghdād afraid of the jealously of his teacher Isḥāq ibn 'Alī al-Mawṣilī. Cordova under Ziryāb's lead became a second Baghdād in setting the fashion to the civilizedworld with refinements indress, *coiffure* and general society life. From the court, music and song spread into the whole country with Muwashshaḥ and Zajal. It was thus that Spain and south-western France become 'music-minded' under Arab influence, for all times. After Ziryāb, Abū al-Qāsim 'Abbās ibn Firnās (d. 888) introduced oriental music and displayed much scientific activity also. He is said to have made the first successful attempt at soaring flight (*i.e.*, flight without the aid of artificial power), putting on a suit of feathers and wings; but after flying a long distance hurt himself in alighting, for want of a steadying tail. This account must not be taken as a 'flight of fancy' on the part of story-tellers. Modern interest in gliding and gliders

will be well rewarded if the original Arabic literature on the subject of 'Abbās ibn Firnās' flight is searched for and carefully studied.[1]

Ibn Firnās is credited also with the building of a planetarium showing stars and even clouds and lightning.

Muslim Spain rose to its pinnacle of glory during the reign of 'Abd al-Raḥmān III, from 912-961, assuming the title of Amīr al-Mu'minīn from 929 onwards. Cordova (Arabic, Qurṭubah) became the centre of learning and culture in Western Europe, for Muslims, Christians and Jews. After Baghdād and Constantinople it was the largest and most flourishing city in the world, and certainly the most advanced of all in its cleanliness, street-lighting and other municipal facilities. No wonder that the German nun Hrostsvitha called it 'the Jewel of the World'. 'Abd al-Raḥmān III, though harassed on all sides by foreign foes at the time of his accession to the throne, overcame all his enemies gradually and completely and

1. Maqqari, Vol. II. p. 254.

left his country in a state of peace and prosperity. He had the co-operation of the Jews from the beginning. Spain was the only country at the time where they found a real home, after prolonged persecutions from the Christian rulers of Europe. They held the highest offices in state administration. Ḥasday ben Sharpūṭ was not only the royal physician but wazīr also. During 'Abd al-Raḥmān's time trade and agriculture developed so remarkably —thanks to his building up a powerful merchant navy and construction of canals—that the royal revenue amounted to 6,245,000 *dīnārs* annually.[1] Qurṭubah with its beautiful gardens, orchards and palaces (al-Zahrā' among others), its magnificent mosques, and well-stocked libraries had a population of half a million inhabitants. Every mosque had its school and education was so liberal that, in the words of Dozy, practically every man could read and write. The University of Cordova attracted men from all parts of the world. Some of the

1. Hitti, *loc. cit.*, p. 525 : Ibn 'Idhārī, Vol. II ; Ibn Khaldūn. Vol. IV.

most distinguished teachers of the time lectured there on theology, literature, mathematics, astronomy, science, medicine and philosophy.

'Abd al-Raḥmān's successor, Ḥakam II was an equally great patron of learning, besides being himself a scholar of the first rank—in fact the foremost scholar-king in Islām. His library contained no less than 400,000 volumes, several of which were embellished by his own marginal notes, and the catalogues of their titles occupied 44 volumes.[1]

After al-Ḥakam Umayyad power began to waver in Spain, but literature, science and the fine arts continued to be cultivated at all the courts of the petty monarchies into which the empire degenerated. A daughter of the Umayyad prince, Muḥammad III al-Mustakfī (d. ca. 1025) the beautiful and highly accomplished al-Wallādah, attained to great renown in the republic of letters. Before her death in 1087 her home in Cordova was the rendezvous of poets and savants. As a matter of fact,

1. Maqqaqrī, Vol. I. pp. 249-250, 256.

according to al-Maqqarī, the women of Andalusia at this time were so well-read that eloquence was a second instinct in them.[1]

When the Banū 'Abbād rose to power in Seville (1023-91) al-Mu'tamīd, who was himself a great poet, chose a friendless wanderer al-'Ammār for his wazīr and a poor country-girl al-I'timād for his favourite queen, primarily on account of their proficiency in the art of poetry.

Yūsuf al-Mu'tamin, Hūdid King of Saragossa from 1081 to 1085, was another great patron of learning. He was himself a good mathematician and wrote a treatise on that subject entitled *Istikmal*, which was pronounced by Judah ibn 'Aqnīn (in the second half of the twelfth century) to be of such a high standard that it should be studied along with Euclid, the Almagest and "the Middle Books". Unfortunately no copy of this royal book is now extent.[2]

Coming down from scholars of princely origin to democratic circles, we propose to begin

1. Maqqari, Vol. II, pp. 536-639.
2. Sarton, *loc. cit.*, Vol. I, p. 759.

with some writers of pure literature, such as the celebrated author of *'Iqd al-Farīd*, Ibn 'Abd Rabbihī (860-940), the laureate of 'Abd al-Raḥmān III, about the importance of whose work some reference has already been made in connection with our sources of knowledge of Arab citizen life. Among scores of learned men professing linguistics at the University of Cordova may be mentioned at-Qālī (901-67) who was educated at Baghdād but found it worth his while to settle in Spain. Foremost among his pupils was Muḥammad ibn al-Ḥasan al-Zubaydī (928-89) of Seville, who was appoined tutor by-al-Ḥakam to his son Hishām, and later wrote a classified list of grammarians and philologists right up to his own time.[1]

Very few people seem to be aware of the fact that the Hebrew grammar was developed in Spain on the model of the Arabic grammar. It retains to this day its Arabic character. Abū Zakariyah Yaḥyā ibn Dā'ūd, a Jewish scholar, who flourished at Cordova and died in the

1. Ibn Khallikān, Vol. II, pp. 338-40.

eleventh century, accomplished this task, translating the technical terms from Arabic into Hebrew.

One of the most prolific of Muslim writers and the greatest scholar of Muslim Spain was 'Alī ibn Ḥazm (994-1064). He passed through many vicissitudes of fortune, serving as wazīr at the courts of the unfortunate representatives of the Umayyad family near its downfall, 'Abd al-Raḥmān V, al-Mustaẓhir and Hishām III al-Mu'tadd. He retired thence to a life of scholarly seclusion and is credited with having written 400 volumes on history and theology, logic, poetry, etc.[1] His *Tawg al-Ḥamamah* is an anthology of love-poems composed probably in his younger days; but his best known work, very catholic and unique up to that, time, *al-Faṣl fi al-Milal wal-Ahwā' wa'l-Niḥāl* deals with comparative religion.

On the downfall of Qurṭubah, a number of provincial cities (seats of petty kingdoms) like Seville, Toledo and Granada rose into power and became university towns, where scholars

1. Ibn Khallikān, Vol. II, p. 22.

and scientists found encouragement and followers.

Abū al-Walīd Aḥmad ibn Zaydūn (1003-71) has been considered by many to be the greatest poet of Spanish Islam. His letters were regarded as a model of grace and erudition. Falling violently in love with the beautiful princess al-Wallādah he got into trouble for a time, but later became Grand Wazīr and Army Commander of the 'Abbāsi prince, al-Mu'taḍid.

Lisān al-Dīn ibn al-Khaṭīb's name can adorn the list of Hispano-Muslim poets as well as historians. He also held the posts of Minister and Commander (hence called Dhū al-Wizārātayn) at the court of the Naṣrid Sulṭān, Yūsuf Abū al-Ḥajjāj (1333-54) and his successor, but afraid of court intrigues fled to Fās, where his enemies strangled him. Though he has written many books on a wide range of subjects, his name is best remembered through his work on the history of Granada, *Iḥāṭah fī Tārīkh Gharnāṭaḥ.*

1. Hitti, *loc. cit.*, p. 567 ; al-Maqqaṛī, *Nafḥ al-Ṭib.*

In historiography we can briefly mention only a few names, for want of space. Abū Bakr ibn 'Umar ibn al-Qūṭīyah, who was born at Cordova and died there in 977, is the author of *Tārīkh Iftitaḥ al-Andalus*, extending from the beginning of Arab conquest to the earlier part of 'Abd al-Raḥmān III's reign. Abū Marwān Ḥayyān ibn Khalaf of Cordova (987-1076) wrote 50 books, one of which *al-Matīn* alone comprised 60 volumes. His *al-Muqtabis fi Tārīkh al-Andalus* has survived.

On the Muwāḥḥid period in Spain and Morocco 'Abd al-Wāḥid al-Marrākusi's history (written in 1224) is considered most valuable. The name of the Hispano-Arab Ṣūfī Abū Bakr Muḥammad ibn 'Alī Muḥayy al-Dīn ibn 'Arabī (al-Shaikh al-Akbar), born in Murcia in 1165, and author of *al-Futūḥāt al-Makkiyah and Fuṣūṣ al-Ḥikam*, etc., is still held in great respect. He died at Damascus in 1240.

Among the foremost biographers of Muslim Spain was Abū al-Walid 'Abdallāh ibn Muḥammad ibn al-Faradi (born in Cordova in

962 and murdered during the sack of the i in 1013), Qāḍī of Valencia and autho *Tārīkh 'Ulamā' Andalus*. The book was s supplemented by Ibn Bashkuwāl Abū al-Q Khalaf ibn 'Abd al-Malik, in 1139 in a vol entitled *al-Ṣilah fi Ṭārīkh Ā'immat al-And* which was in its turn continued by A 'Abdallāh Muḥammad ibn al-Abbār(1199-1 of Valencia and completed with *al-Takm li-Kitāb al-Ṣilah*. Ibn al-Abbār wrote also *Ḥullah al-Siyāra*. Another biographer of n was Abū Ja'far Aḥmad ibn Yaḥyā al-Ḍa (died 1202), author of *Bughyat al-Multami Tārīkh Rijāl al-Andalus*.

Abū al-Qāsim Ṣā'id ibn Aḥmad al-Ṭulay (1029-70), himself a mathematician and ast nomer, compiled a valuable book on the h tory of Science called *Ṭabaqāt al-Umam*, wh served as a source book to later writers.

The most renowned of all historians Western Islam was 'Abd al-Raḥmān ibn Kh dūn (1332-1406), author of *al-'Ibar wa Div al-Mubtadā' wal-Khabar fi Ayyām al-'Arab w*

Ajam wal Barbar, a monumental work on Muslim history of Arabia, Persia, and Northern Africa. Its *Muqaddamah* is a masterpiece of historical criticism on the effect of environment on national development, etc., and an introduction to the philosophy of history. Ibn Khaldūn was of Spanish-Arab extraction, born in Tunis, and held responsible posts at Fās and later at Granada. He returned subsequently to Africa and settling near Ṭilimsān began work on his history. On his way to Cairo, after some years, he was appointed Qāḍī by Barqūq (Mamlūk Sulṭān al-Ẓāhir). When al-Ẓāhir's successor al-Nāṣir led a campaign against Tamerlane, Ibn Khaldūn accompanied him.

The Muslims of Spain made good contribution to our knowledge of geography also. Al-drīsī whose work has already been described was of Hispano-Arab origin. Abū 'Ubayd Abdallāh ibn 'Abd al-'Azīz al-Bākrī, who died at the close of the eleventh century, flourished at Cordova. His *Kitāb al-Masālik wal-Mamālik* written in the form of an itinerary is the

earliest important work of Spanish Arabs
geography. The works of several travelle
like Ibn Jubayr, al-Māzinī and Ibn Baṭṭuṭah a
store-houses of interesting geographical kno
ledge. Ibn Jubayr Abū al-Ḥusayn Muḥamm
ibnAḥmad(born1145)travelledfromGranada
Meccathrough Egypt,Syriaand Iraq,whilethe
three countries were still partly under the gr
of the crusaders, and described his experien
in his book *Riḥlah*. Abū al-Ḥāmid Muḥamma
al-Māzinī (1080-1170) also of Granada, h
described his travels in Russia and the counti
bordering on the River Volga in his *Tuḥf*
al-Albāb, where we are told of trade in foss
bones of the mammoth (ivory) carried on wi
Khwārizm. The greatest traveller of the ea
Muslim world was Ibn Battūṭah who was bo
in Ṭanjah (Tangier) in 1304. He made fo
pilgrimages to Mecca in the second quarter
the fourteenth century and proceeded on
Ceylon, Bengal, the Māldib Islands and ev
as far as China. The Arabs and the Musl
intelligentsia in general were aware of
sphericity of the earth from as early a time

nat of al-Māmūn; Abū 'Ubaydah Muslim al-alinsī has clearly expressed this notion in his ritings in the first half of the tenth century, nd it is from accounts of such travels and ich statements that Columbus drew his spiration to discover America. The prevail-g belief all over Christian Europe in those ays was that the earth was flat.

Spain has produced a number of eminent rab astronomers, among whom we may ention Abū al-Qāsim Maslamaḥ al-Majrīṭī 007) of Cordova who revised and edited al-hwārizmi's Zij; Abū Isḥāq Ibrāhīm ibn Yaḥyā Zarqālī (1028-87) of Toledo, known to the atin world as Arzachel, whose astronomical *ables of Toledo* were very widely known and ed, and whose determination of the Obliquity the Ecliptic is correct to within one minute of c, and the length of the Mediterranean Sea °, much nearer the truth that Ptolemy's aggerated 62°; Jābir ibn Aflāḥ (died ca 1140) Ishbīliah (Seville), Latin name, Geber, who ade important advances in spherical trigono-

metry, was the inventor of an armillary sphe for measuring the positions of the heaven bodies and author of a book on astronomy which the defects of the Ptolemaic system we pointed out and improvements on it attempte Abū Isḥāq Nūr al-Dīn al Biṭrūjī (born Morocco, died in Seville in 1204), Latin nam Alpetraguis, was a pupil of the philosopher Ib Ṭufayl and attempted in his book, 'The Physic Theory of the Planets,' to remove the erro of the Ptolemaic system by putting up a bett explanation of Planetary motion, but witho appreciable success, owing to the tyranny o Aristotelian ideas that heavenly bodies mu move only in circles!

It may be further pointed out that it wa due mainly to the destructive criticisms of a Zarqālī, al-Bitrūjī Naṣīr al-Dīn Ṭusī and other that the Ptolemaic system of astronomy brok down eventually and Copernicus came out bold ly with his helio-centric theory. He refers to h indebtedness to al-Zarqālī and al-Baṭṭanī his book *De Revolutionibus Orbium Clestiu*

In botany we have Abū al-'Abbās al-Nabatī of Seville (b. 1165 or 1171, d.ca. 1239) who made extensive explorations in Spain, along the coast of North Africa, Arabia and the Red Sea, early in the first half of the twelfth century. These he describes in his *Kitāb al-Riḥlah*, and gives a list of new plants that he discovered on the shores of the Red Sea.[1]

The Cordovan physician Abū Ja'far Aḥmad ibn Muḥammad al-Ghāfiqī (died 1165) collected a large number of plants from Spain and Africa and made a first attempt at their classification giving their names in the Arabic, Latin and Berber languages. His work on simples, *al-Adwiyah al-Mufradah*, was largely consulted and made use of by later workers in the same field.

'Abdullāh ibn Aḥmad ibn al-Bayṭār of Malaga (died in 1248 at Damascus), a disciple of Abū al-'Abbās al-Nabātī, is considered to be the greatest botanist and pharmacist of all the Muslims in the East and West. He roamed about Spain and in North Africa in search of

1. Sarton, *loc, cit.*, Vol. II, p. 65.

plants and on being appointed chief herbalis at the court of the Ayyūbid Sulṭān al-Malik al-Kāmil at Cairo continued his search in Syria and Asia Minor. His *al-Mughni fi al-Adwiyah al-Mufradah* (on *materia medica*) and *al-Jāmi fi'al-Adwiyah al-Mufradah* (a collection of simples with their properties, etc.) were dedicated to al-Kāmil's successor al-Ṣāliḥ. The latter work is considered to be the best of its kind in the Middle Ages. Parts of its Latin version were printed in 1758 at Cremona.[1]

Arab and Arabic-speaking physicians of Spain were great scholars in other branches of science as well. A number of them had only an academic interest in medicine. To this class belonged Ibn Rushd (Latin, Averroes), Mūsā ibn Maymūn (Latin, Maimonides), Ibn Bājjah (Laṭin, Avempace) and Ibn Ṭufayl. They will be taken up while discussing philosophy. It may suffice here to remark that when the Black Death ravaged Europe Muslim physicians were quick to find out its infectious nature and Ibn

1. Hitti, *loc., cit.*, p. 576.

al-Khaṭīb (d. 1374) discussed the matter at some length in his *Muqni'at al-Sā'il an Marad al-Ha'il*, and strongly recommended segregation while the Christians stood helpless.[1]

Owing to religious scruples both Muslim physicians and their early Christian colleagues had at first a dislike for vivisection and mutilation of corpses. Their knowledge of anatomy was necessarily poor, hence their aversion to surgery. What little the Muslims knew was from the operations performed on dead bodies of apes. Their greatest surgeon was Abū al-Jarrāḥ Khalaf ibn 'Abbās al-Zahrāwī (died 1013), court physician to al-Ḥakam II. All that was known at the time in this art is embodied in his concise book *al-Taṣrif li man 'Ajaza'an al-Ta'ālif*, like the crushing of stone in the bladder, blood-letting, cauterization, etc.. and included a chapter on surgical instruments also. The surgical portion of this work was translated into Latin by Gerard of Cremona—prince of Latin translators from Arabic. Various editions of the work were published

1. Hitti, *loc. cit.*, p. 576.

in later times; at Venice in 1497, at Basle in 1541 and at Oxford in 1778, and served as a text-book.[1]

An opportunist, 'Abd al-Laṭīf al-Baghdādī (1162-1231) made good study of human skeletons accidentally discovered in a large pit at al-Maks (Egypt) and made note of much important facts revealed thereby.[2] It was at Salerno and especially Bologna that forensic studies grudgingly gave sanction to performing operations on the human corpse and contributed thus so acquisition of sound knowledge of anatomy and surgery.

Al-Zahrāwi's fame as a physician is even surpassed by the distinction attained by Abū Marwān 'Abd al-Malik ibn Abī al-'Alā ibn Zuhr (Latin, Avenzoar) in pure medicine. He was born at Seville sometimes between 1091 and 1094 and was the most distinguished member of an illustrious family of Spanish physicians. For a long time he graced the court of the founder of the al-Muwaḥḥid dynasty,

1. Hitti, *loc. cit.*, p. 557.
2. Sarton, *loc. cit.*, Vol. II, p. 599.

'Abd al-Mu'min, as Wazīr and private physician. He was a friend of Ibn Rushd and at his request wrote *al-Taysīr fi Mudāwah w'al-Tadbīr*, a work of great merit.

Out of a long list of Hispano-Arabic philosophers we can mention only a few. Ibn Jabīrūl (Sulayman ibn Yaḥyā, Ben Gabirol, born 1021) long known as the Jewish Plato, though not an Arab, wrote in Arabic his famous *Yanbu' al-Ḥayāt*, rendered into Latin as *Fons Vitae*, a work which had much influence on the scholasticism of the Middle Ages (Franciscan Friars are believed to have based some of their ideas on its teachings). Ibn Maymūn, a Jew (born in Cordova in 1135), author of *al-Faṣul fī al-Ṭibb* and *Dalālat al-Ha'irīn*; Abū Bakr Muḥammad ibn Bājjah (Latin, Avempace, died 1138), author of *Tadbīr al-Mutawaḥḥid*, Abū Bakr Muḥammad ibn 'Abd al-Malik ibn Ṭufayl (died in Morocco in 1185), Wazīr and court physician to the al-Muwaḥḥid rule of Spain and Africa, Abu Ya'qūb Yūsuf and author of the intellectual romance *Ḥayy ibn Yaqẓān*; and Abu al-Walīd

Muḥammad ibn Aḥmad ibn Rushd (the famous Averroes of Medieval Europe), author of *Tahafut al-Tahāfut* (the Incoherence of Incoherence, written in answer to al-Ghazzālī's *Tahāfut al-Falāsifaḥ*). Jāmi', *Fafsir wa Kulliāt fi al-Ṭibb* are great names in the realm of philosophy. We are unable to give even a brief account of their philosophical works beyond saying that Ibn Ṭufayl's *Ḥayy ibn Yaqẓān*, first translated into English from original Arabic by Simon Ockley, is now available in a revised form with a delightful introduction by S. A. Fulton (published by Chapman and Hall, London). It is a bold attempt to bring the main beliefs of revealed religion into alignment with rationalistic ideas.

Ibn Rushd's (b. 1126 in Cordova, d. 1198 in Marrākish) name, at one time considered second only to that of Aristotle in the West, has still a high place of honour in the continental schools of philosophy in Europe. As he was a keen observer of nature and natural phenomena he was the first to discover the retina to be the real seat of perception of light

and vision. He is credited also with the discovery of Sunspots.[1] For a casual observer to witness the phenomenon with the unaided eye, presumably at sunrise or sunset, it must have been an unusually large spot, and knowledge of the years of Ibn Rushd's observation may lead to interesting relationship between Sunspotactivity and some allied meteorological phenomena. Ibn Rushd's *Kulliyāt fi al-Tibb* (Latin, Colliget) deals with medicine and allied subjects.

1. J. W. Draper, *Intellectual Development of Europe*. 2 Volumes (revised edition).

X

TRANSMISSION OF ARAB LEARNING AND CULTURE TO CHRISTIAN EUROPE

A number of distinguished historians and scientific investigators (like John William Draper, Guizot, John Davenport, Stanley Lane-Poole, M.P.E. Berthelot and more recently E.J. Holmyard, Max Meyerhof, George Sarton and Philip K. Hitti) have fully acknowledged the part played by the Arabs and their Muslim collaborators from other nationalities in not only preserving the knowledge of ancient Greece, Persia and India but adding enormously to it. We take this opportunity of expressing our personal indebtedness to these authors, especially the last two (in addition, of course, to the standard Arabic sources), for the bulk of information incorporated in this brief sketch. Even a cursory acquaintance with Muslim history cannot fail to impress one with admiration for Arab enterprise and achieve-

ment in all fields of humar activity. From the beginning of the eighth to the end of the fourteenth century the Arabs were eager to acquire knowledge and to share it with all others who would care to go to them for it. Their scientists and philosophers marched into foreign countries almost simultaneously with their generals and preachers. Even when they degenerated politically they continued to be the torch-bearers of learning for generations. It was thus the wild Daylamites, Saljūqs, Tartars and Berbers, once they came into contact with the civilization of Islam, settled down to peaceful pursuits and assimilation of Arab Culture. The greatest calamity that the Muslim world suffered was from the Tartar hordes under Changiz Khan and Hulāgū and yet these aggressors (like the fanatical Crusaders) were stopped by the Mamlūk Sulṭāns of Egypt who were recruited primarily from as rough and uncivilized a stock as the Tartars themselves.

Egypt and Syria will for ever proclaim the glory of Ṣalāḥ al-Dīn (b. in Takrit, 1138, d. March 1193), Rukn al-Dīn Baybars (1260-77)

and Sayf al-Dīn Qalā'ūn (1279-90) not only for their overcoming the Crusaders, but for their encouragement of learning, fine arts and architecture, their schools, hospitals and canals.

It is interesting to see how Arab learning and culture spread through Europe. Sicily and Spain were the principal sources of propagation. From Sicily, its two "baptised Sulṭāns" Roger II and Frederick II, Hohenstaufen, especially the latter, carried Arab culture through Italy across the Alps, Lotharingia (Lorraine), Liege, Gorze and Cologne becoming centres of Arab learning. From Spain it penetrated beyond the Pyrenees into Western and South-Western France, slowly but surely. When the Arabs came to a halt in their output of scientific work, roughly at the beginning of the thirteenth century, Christian Europe was learning medicine, mathematics, astronomy, physics and chemistry through its students returning home from the Universities of Cordova, Toledo, Seville and Granada. Marvellously industrious translators like

Gerard of Cremona, Adelard of Bath, Robert of Chester, Michael Scot, Stephen of Saragossa, William of Lunis, Philip of Tripoli and a host of others, made Arab lore available to Latin-knowing people through their laborious translations. Some books were translated into Hebrew also and from Latin or Hebrew into the vernacular languages of Europe.

The study of medicine in Europe began at Salerno where Constantine, the African, who was lucky in having an Arab for his teacher, organised the first medical school. Montpellier and Paris soon followed suit. Arabic, being the chief medium of scientific thought practically all over the world, was taught systematically in several European Universities and schools, especially at Toledo, Narbonne, Naples Bologna and Paris.

According to some authorities scientific agriculture spread over France and her neighbouring countries from Arab Spain and over Italy from Arab Sicily. The system of irrigation introduced by the Muslim rulers of Spain and their love of horticulture soon made the

country a veritable garden. A relic of thi activity is preserved in a work called *Kitab a Falahat* by Abū Zakarīya ibn Muḥammad ib al-'Awwām Ishbīli—though the actual flourish ing orchards and flower-gardens of old hav now vanished altogether. In this book no les than 585 plants are described, with instruction for the nursing, rearing and manuring of mor than fifty fruit trees.[1] The Arabs introduced the cultivation of rice, sugarcane, cotton, orange and a number of other useful plants in Spain. Their textile industry was renowned all over the continent and so was the temper of their sword blades. By far the most important contribution to civilisation for which Europe will be for ever indebted to them is the introduction of paper manufacture. They seem to have learnt this art from the Chinese in the eighth century and carried it over to Samarqand and Baghdād. From there it reached Morocco in the eleventh century and then crossing the strait of Gibraltar flourished at Shāṭibah in Spain.[2] The oldest paper manuscript on record

1. Urdu translation by Sayyid Hāshim Nadwi (Ma'ā Press, A'zamgarh).
2. Yāqūt. Vol III, p 235.

that is preserved, is said to be that of 'Ubayd-Allāh al-Qāsim ibn Sallām (died 837), entitled *Gharīb al-Ḥadīth*, dated Dhu'al-Qa'dah 252 A.H. (corresponding to 13th November or 12th December, 866).[1]

For generation after the recovery of their provinces from the Arab Spanish Christians, both monarchs and their subjects continued to study Arabic and conduct most of their intellectual work in that language. A very remarkable example of this propensity is on record. On the Murābiṭ *dinar* was impressed on the obverse side *Amīr al-Muslimīn* and on the reverse side *Imān* with the name of the Banī 'Abbāsiah Khalīfah. In imitation of this, Alfonso the eighth of Leon and Castile (1168-1214) adopted on the corresponding sides of his own *dinar* in Arab characters the analogous words *Amīr al-Qatulaqīn* and *Imām al-Bai'ah al-Masīḥiyah*.[2]

Many technical terms in medicine, astro-

1. Hitti, *loc cit.*, p. 347.
2 *Ibid.*, p. 542

nomy, chemistry and other sciences still continue to be Arabic. A number of non-technical words of several European languages also have been borrowed from that language, through modified and disguised but easily discernible to anyone possessing good etymological knowledge.

Foremost among the scientific terms are the names of the stars. It is a pity that most of them have been badly distorted or ruthlessly abbreviated, so as to lose much of their original significance. As examples we may cite Achernar for Ākhir al-Nahr, Fomal haut for Famm al-Ḥūṭ, Āega for 'Nasr al-Wāqi', Altair for Nasr al-Ṭair, Daneb for Dhanab al-Dujājah and Denebola for Dhanab al-Asad, etc.

THE END

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