History of Islamic Science

George Sarton's Tribute to Muslim Scientists in the "Introduction to the History of Science,"
"It will suffice here to evoke a few glorious names without contemporary equivalents in the West: ***Jabir ibn Haiyan****,* ***al-Kindi****,* ***al-Khwarizmi****,* ***al-Fargani****,* ***Al-Razi****,* ***Thabit ibn Qurra****,* ***al-Battani****,* ***Hunain ibn Ishaq****,* ***al-Farabi****,* ***Ibrahim ibn Sinan****,* ***al-Masudi****,* ***al-Tabari****,* ***Abul Wafa****,* ***'Ali ibn Abbas****,* ***Abul Qasim****,* ***Ibn al-Jazzar****,* ***al-Biruni****,* ***Ibn Sina****,* ***Ibn Yunus****,* ***al-Kashi****,* ***Ibn al-Haitham****,* ***'Ali Ibn 'Isa al-Ghazali****,* ***al-zarqab****,****Omar Khayyam****. A magnificent array of names which it would not be difficult to extend. If anyone tells you that the Middle Ages were scientifically sterile, just quote these men to him, all of whom flourished*
within a short period, 750 to 1100 A.D."

Preface

On 8 June, A.D. 632, the **Prophet Mohammed** (Peace and Prayers be upon Him) died, having accomplished the marvelous task of uniting the tribes of Arabia into a homogeneous and powerful nation.

In the interval, Persia, Asia Minor, Syria, Palestine, Egypt, the whole North Africa, Gibraltar and Spain had been submitted to the Islamic State, and a new civilization had been established.

The Arabs quickly assimilated the culture and knowledge of the peoples they ruled, while the latter in turn - Persians, Syrians, Copts, Berbers, and others - adopted the Arabic language. The nationality of the Muslim thus became submerged, and the term Arab acquired a linguistic sense rather than a strictly ethnological one.

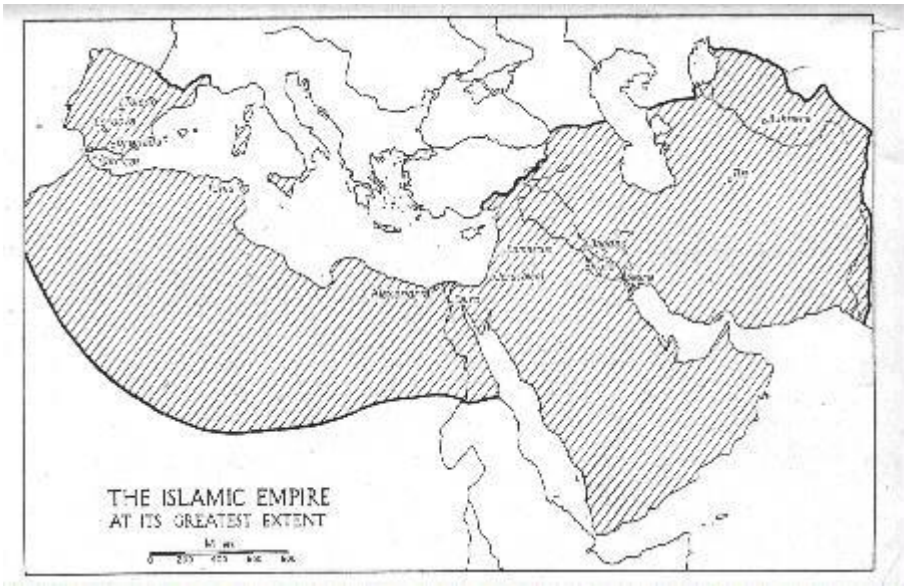
As soon as Islamic state had been established, the Arabs began to encourage learning of all kinds. Schools, colleges, libraries, observatories and hospitals were built throughout the whole Islamic state, and were adequately staffed and endowed.

In the same time, scholars were invited to Damascus and Baghdad without distinction of nationality or creed. Greek manuscripts were acquired in large numbers and were studied, translated and provided with scholarly and illuminating commentaries.

The old learning was thus infused with a new vigor, and the intellectual freedom of men of the desert stimulated the search for knowledge and science.

In early days at least, the Muslims were eager seekers for knowledge, and Baghdad was the intellectual center of the world.

Historians have justly remarked that the school of Baghdad was characterized by a new scientific spirit. Proceeding from the known to the unknown; taking precise account of phenomena; accepting nothing as true which was not confirmed by experience, or established by experiment, such were fundamental principles taught and acclaimed by the masters of the sciences.



The Islamic Empire At Its Greatest Extent 750 c

George Sarton in his introduction, marks the time from the 2nd half of eighth century to the 2nd half of the eleventh century into:

- The time of Jabir Ibn Haiyan which covers the 2nd half of eighth century
- The time of Al-Khwarizmi which covers the 1st half of ninth century
- The time of Al-Razi which covers the 2nd half of ninth century
- The time of Al-Mas'udi which covers the 1st half of tenth century
- The time of Abu-l-Wafa which covers the 2nd half of tenth century
- The time of Al-Biruni which covers the 1st half eleventh century
- The time of Omar Khyyam which covers the 2nd half of eleventh century

The Time of **Jabir Ibn Haiyan**
Second half of Eighth Century

The intellectual relaxation which characterized the second half of the seventh century and the first half of the eighth was followed by a period of renewed activity which was entirely due to Muslim initiatives, that is why this period gave an Arabic name marking the beginning of Muslim science. The name Jabir Ibn Haiyan came from the highly important contributions by him in this period. Jabir's texts, whether in Arabic or Latin, are one of the most urgent and promising tasks of scholarship. He will remain a very impressive personality.

Imaginative portrait of **Jabir Ibn Haiyan**
(Photograph, A. Chelazzi, Florence,...*Makers of Chemistry*, E. L. Holmyard)

Cultural Background of this Period in the East

Two rulers of the Abbasid caliphs used their authority to promote the intellectual welfare and progress of the peoples, and distinguished themselves greatly in this respect; the second, **Al-Mansur** (founded Baghdad) and the fifth, **Harun Al-Rashid** (whose fame has been immortalized by many legends). Both caliphs encourage the work of translators who were busily unlocking the treasures of Greek knowledge.
Abu Ja'far 'Abdallah Al-Mansur, i.e. the victorious. Died in 775 at Bir Maimun, near Mecca, at the age of 63 - 68 Muslim years (Hegra), i.e. 61-66 Christian years. He was the second 'Abbasid caliph and ruled from 754 to his death.
He was a great statesman and the founder of Baghdad. Memorable because of the many translations from the Syriac, Persian, Greek, and Hindu languages into the Arabic which were accomplished in his reign.
Harun Al-Rashid, born in 763 or 766 at al-Ray; died at Tus in 809. Caliph from 786 to his death; the fifth and one of the greatest 'Abbasid monarchs. Magnificent patron of science, art, and literature. Many more Greek works were translated by his order. In 807 he presented a very remarkable water-clock to Charlemange (King of the Franks since 768; crowned Emperor of the West on Christmas 800 by Leo III in Rome)

Islamic Mathematics and Astronomy

All of the mathematical and astronomical work of this period was done by Muslims. It is interesting to recall that the mathematical work of the previous period had been done almost exclusively by Chinese. Some amount of stimulation had come from India. In addition to transmission of some Hindu mathematics.
Ibrahim al-Fazari is said to have been the first Muslim to construct astrolabes.

Ya'qub ibn Tariq and **Muhammad, son of Ibrahim al-Fazari**, are the first to be mentioned in connection with Hindu mathematics: Ya'qab met at the court of al-Mansur, a Hindu astronomer called Kankah (?), who acquainted him with the *Siddhanta*, and Muhammad was ordered to translate it. The physician al-Batriq translated Ptolemy's *Quadripartitum*. Two astrologers, one of them a Jew named Mashallah, the other a Persian called **Al-Naubakht**, worked together to make the measurements necessary for the building of Bagdad. **Al-Naubakht**'s son, **Al-Fadl**, wrote astrological treatises and translations from the Persian into Arabic.

Ibrahim al-Fazari
Abu Ishaq Ibrahlm ibn Habib ibn Sulaiman ibn Samura ibn Jundab. Died c. 777.
Muslim astronomer. The first to construct astrolabes, he wa the author of a poem (qasida) on astrology and of various astronomical writings (on the astrolabe, on the armillary spheres, on the calendar). H. Suter: *Die Mathematiker und Astronomer der Araber* (3, 208, 1900)

Ya'qub Ibn Tariq
Probably of Persian origin, flourished in Baghdad, c.767-778 died c. 796. One of the greatest astronomers of his time. He probably met, c. 767, at the court of **Al-Mansur**, the Hindu Kankah (or Mankah?), who had brought there the *Siddhanta*. He wrote memoirs on the sphere (c. 777), on the division of the kardaja; on the tables derived from the *Siddhanta*. H. Suter: *Die Mathematiker und Astronomer der Araber* (p. 4, 1900)

Muhammad Ibn Ibrahim Al-Fazari
Abu 'Abdallah Muhammad ibn Ibrahim al-Fazari. Son of the astronomer Ibrahim dealt with above, for whom he is sometimes mistaken (he may be the author of the astrological poem ascribed to his father). Died c. 796 to 806. Muslim scientist and astronomer. He was ordered by the Caliph **Al-Mansur** in 772/3 to translate the Sanskrit astronomical work Siddhanta. This translation was possibly the vehicle by means of which the Hindu numerals were transmitted from India to Islam.
H. Suter: *Die Mathematiker und Astronomen der Araber* (p. 4,1900).
Cantor: *Geschichte der Mathematik* (I, 3rd ed., 698, 1907).
D. E. Smith and L. C. Karpinski: *The Hindu-Arabic Numerals* (p.92, Boston, 1911)

Mashallah
His real name was probably Manasseh (in Arabic, Misha). Latin translators named him Messahala (with many variants, as Macellama, Macelarma). Mashallah is a contraction of ma'aha Allah meaning "What wonders Allah has willed." (What hath God wrought.) Flourished under al-Mansur, died c. 815 or 820. One of the earliest astronomers and astrologers in Islam, himself an Egyptian (?) Jew. Only one of his writings is extant in Arabic, but there are many mediaeval Latin and Hebrew translations. The Arabic text extant deals with the prices of wares and is the earliest book of its kind in that language. He took

part with the Persian astrologer **Al-Naubakht** in the surveying preliminary to the foundation of Baghdad in 762-63. His most popular book in the Middle Ages was the 'De scientia motus orbis', translated by Gherardo Cremonese.
Text and Translation. The *De scientia motus orbis* is probably the treatise called in Arabic "the twenty-seventh;" printed in Nuremberg 1501, 1549. The second edition is entitled: 'De elementis et orbibus coelestibus', and contains 27 chapters. The De compositione et utilitate astrolabii was included in Gregor Reisch: *Margarita phylosophica* (ed. pr., Freiburg, 1503; Suter says the text is included in the Basel edition of 1583). Other astronomical and astrological writings are quoted by Suter and Steinsehneider.
An Irish astronomical tract based in part on a mediaeval Latin version of a world by Messahalah. Edited with preface, translation, and glossary, by Afaula Power (*Irish Texts Society*, vol. 14, 194 p., 1914. A relatively modern translation of the *De scientia motus orbis*, the preface is uncritical).


Astrolabe


Astronomers Using Astrolabe

Islamic Alchemy

It is noteworthy that the earliest alchemical texts in Arabic and Latin are contemporaneous, that is, if our dating of them is correct. The most famous alchemist of Islam, Jabir Ibn Haiyan, seems to have had a good experimental knowledge of a number chemical facts; he was also an able theoretician.

Jabir ibn Haiyan
Abu Musa Jabir ibn Haiyan al-Azdi (al-Tusi, al-Tartusi; al-Harrani meaning that he was a Sabian?; al-Sufi). Flourished mostly in Kufa, c. 776, he was the most famous Arabic alchemist; the alchemist Geber of the Middle Ages. He may be the author of a book on the astrolabe, but his fame rests on his alchemical writings preserved in Arabic: the "Book of the Kingdom," the "Little Book of the Balances," the "Book of Mercy," the "Book of Concentration," the "Book of Eastern Mercury," and others. According to the treatises already translated (by Berthelot), his alchemical doctrines were very anthropomorphic and animistic. But other treatises (not yet available in translation) show him in a better light. We find in them remarkably sound views on methods of chemical research; a theory on the geological formation of metals; the so-called sulphur-mercury theory of metals (the six metals differ essentially because of different proportions of sulphur and mercury in them); preparation of various substances (e.g. basic lead carbonate; arsenic and antimony from their sulphides).

Jabir also deals with various applications, e.g. refinement of metals, preparation of steel, dyeing of cloth and leather, varnishes to water-proof cloth and protect iron, use of manganese dioxide in glass making, use of iron pyrites for writing in gold, distillation of vinegar to concentrate acetic acid. He observed the imponderability of magnetic force.

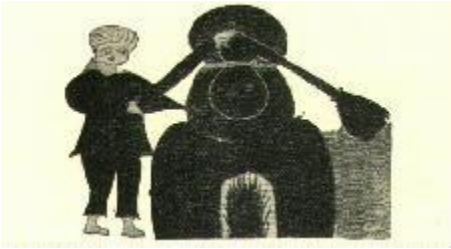
It is possible that some of the facts mentioned in the Latin works, ascribed to Geber and dating from the twelfth century and later, must also be placed to Jabir's credit. It is impossible to reach definite conclusions until all the Arabic writings ascribed to Jabir have been properly edited and discussed. It is only then that we shall be able to measure the full extent of his contributions, but even on the slender basis of our present knowledge, Jabir appears already as a very great personality, one of the greatest in mediaeval science.

Text and Translations:- M. Berthelot: *La chimie au moyen age* (vol. 3, L'alchimie arabe, Paris,1893. The Arabic text of a few of Jabir's writings is edited by Octave Houdas. French translation, p. 126-224. See E. J. Holmyard's criticism in *Isis*, XI, 479-499, 1924). Ernst Darmstaedter: *Die Alchemie des Geber* (212 p., 10 pl.; Berlin, 1922. German translation of the Latin treatises ascribed to Geber; reviewed by J. Ruska in *Isis*, V, 451-455, concluding that these Latin treatises are apocryphal); Liber misericordiae Geber. Eine lateinisehe ubersetzung des grosseren Kitab al-rahma (Archive fur Geschichte der Medizin, vol. 17, 181-197, 1925; *Isis*, VIII, 737).

Page of one of Jabir's Chemical Works in Arabic

Fig. 19. FIGURES OF ALCHEMICAL PROCESSES IN ARABIC MANUSCRIPT

Figures of some Alchemical Processes in ArabicManuscript



An illustration from an Arabic Manuscript in the British Museum

*Portrait of **Jabir Ibn Haiyan** by an Egyptian artist*

The Time of **Al-Khwarizmi**
"First Half of Ninth Century"

The ninth century was essentially a Muslim century. To be sure, intellectual work did not cease in other centuries; but the activity of the Muslim scholars and men of science was overwhelmingly superior. They were the real standard-bearers of civilization in those days. Their activity was superior in almost every respect. To consider only the first half of the century, the leading men of science, **Al-Kindi**, **The sons of Musa**, **Al-Khwarzmi**, **Al-Farghani**, were all Muslims; **Ibn Masawaih**, it is true, was a christian, but he wrote in Arabic.

Cultural Background

The seventh Abbasid caliph, al-Ma'mun (813-833), was even a greater patron of letters and science than Harun al-Rashid. He founded a scientific academy in Bagdad, tried to collect as many Greek manuscripts as possible, and ordered their translation; he encouraged scholars from all kinds, and an enormous amount of scientific work was done under his patronage.

Al-Ma'mun
'Abdallah al-Ma'mun. Born in Baghdad in 786, died near Tarsus in 833. The seventh and greatest 'Abbasid caliph (813-833). His mother and wife were Persians, which explains his Persian and 'Alid proclivities. He was an ardent Mu'tazil, who tried to enforce his views by means of violence. He wrote four long letters to explain the Qur'an was created, and he cruelly punished those who dared entertain different views (e.g., **Ibn Hannibal**). He thus combined in a remarkable way free thought and intolerance. While persecuting those who objected to Mu'tazilism, Jews and Christians were very welcome at his court.

Al-Ma'mun was even a greater patron of letters and science than **Harun Al-Rashid**. He took considerable pains to obtain Greek manuscripts and even sent a mission to the Byzantine Emperor Leon the Armenian (8l3 to 890) for that purpose. He ordered the translation of these manuscripts. He organized at Baghdad a sort of scientific academy called the House of Wisdom (Bayt al-hilkma), which included a library and an observatory. This was the most ambitious undertaking of its kind since the foundation of the Alexandrian Museum (q. v. first half of third century B. C.).

Al-Ma'mun built another observatory on the plain of Tadmor (Palmyra). The inclination of the ecliptic was found by his astronomers to equal 23o 33' and tables of the planetary motions were constructed. He ordered two degree-measurements to be made to determine the size of the earth one of them near Tadmor (a degree = 6,500 miles) hence circumference of the earth = 20,400 miles; diameter=6,500 miles). A large map of the world was drawn for him. He encouraged philosophers, philologists, traditionalists, and other jurists mathematicians, physicians, astrologers and alchemists.

Fihrist (116, 24.3 and passim). Gustav Weil: Gesehichte (ler Chalifen (vol.2 198-994). J. T. Remaud: Geographie d'Aboulfeda (vol. 1, 269 sq. 1848). J. L. E. Dreyer: History of the Planetary System from Thales to Kepler (p. 245, 249 278 Cambridge, 1906) R. A. Nicholson: Literary History of the Arabs (359 1907).

An Encyclopedic Scientist.... **Al-Kindi**

Abu Ysuf Ya'qub ibn Ishaq ibn al-Sabbah al-Kindi (i. e., of the tribe of Kinda) Latin name, Alkindus. Born in Basra at the beginning of the ninth century, flourished in Baghdad under al-Ma'mun and al-Mu'tasim (8l3 to 849), persecuted during the orthodox reaction led by **Al-Mutawakkil** (841 to 861); died c. 873. "The philosopher of the Arabs;" so-called probably because he was the first and only great philosopher of the Arab race. His knowledge of Greek science and philosophy was considerable. He made a deep study of Aristotle from Neoplatonic point of view. Relatively few of his numerous works (270?) are extant. They deal with mathematics, astrology , physics, music, medicine, pharmacy, and geography.

Al-Kindi wrote four books on the use of the Hindu numerals. Many translations from the Greek into Arabic were made or revised by him or under his direction. He considered a1chemy as an imposture. Two of his writings are especially important: "De aspectibus," a treatise on geometrical and physiological optics (largely based on Euclid, Heron, Ptolemy; no dioptrics), which influenced Roger Bacon, Witelo, etc.; "De medicinarum compositarum gradibus," an extraordinary attempt to establish posology on a mathematical basis. He is the earliest Muslim .writer on music whose works have come down to us; they contain a notation for the determination of pitch. Many writings of his were translated into Latin by Gherardo da Cremona. His influence was long felt and Cardano considered him as one of the twelve greatest minds.

Text and Translation - The De medicinarum compositarum gradibus investigandis libellus was published in Strassburg (1531) Die philosophischen Abhandlungen des **Al-Kindi**. Zum ersten Male hrg . von Albino Nagy (Beitr. zur Gesch. d. Philos. des Mittelalters, II, 5, 118 p., Munster, 1897.

Islamic Mathematics and Astronomy

A very large amount of mathematical and astronomical work was done during third period. chiefly by Muslims. It is practically impossible to separate mathematics from astronomy, for almost every mathematician was an astronomer or an astrologer, or both. Some of the most important steps forward were made in the field of trigonometry in the course of computing astronomical tables. Thus it is better to consider mathematicians and astronomers at one and the same time, but they are so numerous that **G.Sarton** have divided them into five groups, as follows: the geometers, the arithmeticians and algebraists, the translators of the "Almagest," the astronomers and trigonometricians, the astrologers. It is hardly necessary to say that these groups are not exclusive, but overlap in various ways.

Geometers **Al-Hajjaj ibn Yusuf** was the first translator of Euclid's "Elements 'into Arabic . **Al-'Abbas** wrote commentaries upon them . **Abu Sa'id Al-Darir** wrote a treatise on geometrical problems. Two of the Banu Musa, Muhammad and Hasan, were especially interested in geometry; the third, Ahmad, was a student of mechanics. Books on the measurement of the sphere, the trisection of the angle, and the determination of two mean proportionals between two given quantities are ascribed to them. They discovered kinematical methods of trisecting angles and of drawing ellipses.

Arithmeticians and Algebraists The Jewish astrologer Sahl ibn Bishr wrote a treatise on algebra. The greatest mathematician of the time, and, if one takes all circumstances into account, one of the greatest of the times was **Al-Khwarazmi**. He combined the results obtained by the Greeks and the Hindus and thus transmitted a body of arithmetical and algebraic knowledge which exerted a deep influence upon mediaeval mathematics. His works were perhaps the main channel through which the Hindu numerals became known in the west. The philosopher al-Kind1 wrote various mathematical treatises, including four books on the use of Hindu numerals. This may have been another source of Western knowledge on the subject. In any ease, the Arabic transmission eclipsed the Hindu origin, and these numerals were finally known in the West as Arabic numerals.

Translators of the "Almagest" The earliest translator of the "Almagest" into Arabic was the Jew **Sahl al-Tabari**. Another translation was made a little later (in 829), on the basis of a Syriae version, by A**l-Hajjaj ibn Yusuf**.

Astronomers and Trigonometricians **Ahmad Al-Nahawandi** made astronomical observations at Jundishapur and compiled tables. The Caliph **Al-Ma'mun** built an observatory in Baghdad and another in the plain of Tadmor. His patronage stimulated astronomical observations of every kind. Tables of planetary motions were compiled, the obliquity of the ecliptic determined, and geodetic measurements carefully made.

Al-Khwarizmi was one of the first to compute astronomical and trigonometrical tables. **Habash al-Hasib** seems to have been one of the greatest astronomers working for **Al-Ma'mun**. He edited three astronomical tables, seems to have been the first to determine the time by an altitude, and introduced the notion of shadow (umbra versa) corresponding to our tangent.
He compiled a table of tangents, probably the earliest of its kind. **Sanad ibn 'Ali** was the chief of **Al-Ma'mun**'s astronomers. Astronomical tables were compiled by him and by **Yahya ibn abi Mansur**, it is probable that those tables (and those of Habash already quoted) were due to the cooperative efforts of many astronorners. Observations were made by the geometers **Al-'Abbas**, '**Ali ibn Isa al-Asturlabi**,

Yahya ibn abi Mansur, **Al-Marwarrudhi**, and **Al-Khwarizmi**; also the observations made by **Al-Dinawari** in 845-50 in Ispahan.

The geometer **Abu Sa'id al Darir** wrote a treatise on the drawing of the meridian.
'Al. ibn 'Isa al-Asturlabi was a famous maker of instruments; he wrote 3 treatise on the astrolabe. But by far the most notable of that distinguished company was **Al-Fargham** (Alfraganus). He was apparently the first Muslim to write a : comprehensive treatise on astronomy. That treatise was very popular until the fifteenth century; it influenced not only the Muslim, but also, through Latin and Hebrew translations, the Christian and Jewish astronomers.

Astrologers It is safe to assume that every astronomer was also, incidentally an astrologer. There are a few popular men, throughout the Middle Ages, who were chiefly if not exclusively concerned with astrology, they contributed powerfully to its debasement, The main astrologers of this period were 'Umar ibn al-Farrukhan and his son Muhammad **Abu Ma'shar** (Albumasar), **Sahl ibn Bishr**, and **Abu Ali al-Khaiyat**.

Muslim Mathematicans and Astronomers

Al-Hajjaj ihn Yusuf
Al-Hajjaj ihn Yusuf ibn Matar. Flourished some time between 786 and 833. probably in Baghdad. The first translator of Eucelid's "Elements" into Arabic and one ef the first translators of the "Almagest." kitab al-mijisti, hence our word almagest). Al-Hajjaj's translation of the Almagest was made in 829-8.90 on the basis of a Syriac version (by Sergios of Resaina" (first half of sixth century). A later adaptation of the Almagest was made by **Abu-l-Wafa**' (second half of tenth century) .
He twice translated the "Elements" of **Euclid**, first under **Harun al-Rashid** then again under **Al-Ma'mun**.

Al-'Abbas ibn Sa'id
al-'Abbas ibn Sa'id al-Jauhari. Flourished under **Al-Ma'mun**. Muslim mathematician and astronomer. He took part in the astronomical observations organized at Baghdad in 829.30 and at Damaseus in 832-833. He wrote commentaries on Euclid's Elements.
H. Suter: :Mathematiker (12, 1900)

Abu Sa'id al-Darir
Abu Sa'id al-Darir al-Jurajani. who died in 845/6; thus he flourished in the first half of the ninth century. Muslim astronomer and mathematician. He wrote a treatise on geometrical problems and another on the drawing of the meridian.
H. Suter: :Mathematiker (12, 1900).

Al-Khwarizmi

Abu ‘Abdallah Muhammad ibn Musa al-Khwarizmi. The last-mentioned name (his nisba) refers to his birthplace, Khwarizm, modern Khiva, south of the Aral Sea. It is under that name that he was best known, as is witnessed by the words algorism and augrim (Chaucer) derived from it. Flourished under al-Ma’mun, caliph from 813 to 833, died c. 850.

Al-Khwarizmi was a Muslim mathematician, astronomer, geographer one of the greatest scientists of his faith and the greatest of his time. He syneretized Greek and Hindu knowledge and influenced mathematical thought to a greater extent than any other mediaeval writer. His arithmetic (lost in Arabic; Latin translation of the twelfth century extant) made known to the Arabs and Europeans the Hindu system of numeration. His algebra, Hisab al-jabr wal-muqabala, is equally important. It contains analytical solutions of linear and quadratic equations and its author may be called one of the founders of analysis or algebra as distinct from geometry.

Al-Khwarizmi also gives geometrical solutions (with figures) of quadratic equations, for ex., X2 + 1OX = 39, an equation often repeated by later writers. The Liber ysagogarum Alchorismi in artem astronomicam a magistro A. [Adelard of Bath ?] compositus!’ deals with arithmetic, geometry. music, and astronomy; it is possibly a summary of al-Khwarzmi’s teachings rather than an original work. His astronomical and trigonometric tables, revised by **Maslama al-Majrti** (Second half of tenth century), were translated into Latin as early as l126 by Adelard of Bath. They were the first Muslim tables and contained not simply the sine function but also the tangent (Maslama’s interpolation). Al-Khwarizmui probably collaborated in the degree measurements ordered by **Al-Ma’mun**. He improved Ptolemy’s geography, both the text and the maps (Surat al-ard, “The Face of the Earth”).

General Studies Fihrist (p. 274 and comm.). H. Suter: Die Mathematiker und Astronomen der Araber (l0, 1900); Nachtrage (158-160, 1902). L. C. Karpinski’s edition of the Algebra (1915.)

Sahl Al-Tabari

Also called Rabban al-Tabari, meaning the Rabbi of Tabaristan. Flourished about the beginning of the ninth century. Jewish astronomer and physician. The first translator of the Almagest into Arabic.
H. Suter: Die Mathematiker und Astronomen der Araber (l0, 1900); M. Steinschneider: Die arabische Literatur der Juden (23-34, Frankfurt, 1902).

Ahmed Al-Nahawandi

Ahmad ibn Muhammad al-Nahawandi. Flourished at Jundishapur at the time of Yahva ibn Khalid ibn Barmak, who died in 802-3; he himself died c. 835 to 845. Muslim astronomer. He made astronomical observations at Jundishapur and compiled tables called the comprehensive (Mushtamil).

H. Suter: Die Mathematiker und Astronomen der Araber (l0, 1900)

Habash Al-Hasib

Ahmad ibn 'Abdallah al-Marwazi (i. e., from Merv) Habash al-Hasib (the calculator). Flourished in Baghdad; died a centenarian between 864 and 874. Astronomer under **Al-Ma'mun** and **Al-Mu'tasim**. (He observed from 825 to 835) He compiled three astronomical tables: the first were still in the Hindu manner; the second, called the 'tested" tables, were the most important; they are likely identical with the "Ma'munic" or "Arabic" tables and may be a collective work of **Al-Ma'mun**'s astronomers; the third, called tables of the Shah, were smaller. Apropos of the solar eclipse of 829, Habash gives us the first instance of a determination of time by an altitude (in this case, of the sun); a method which was generally adopted by Muslim astronomers. He seems to have introduced the notion of "shadow," umbra (versa), equivalent to our tangent, and he compiled a table of such shadow which seems to be the earliest of its kind.

Islamic Alchemy, Physics, and Technology

The astronomer ***Sanad ibn 'Ali*** is said to have made investigations on specific gravity. ***Al-Kindi*** wrote a treatise on geometrical and physiological optics; he criticized alchemy. His writings on music are the earliest of their kind extant in Arabic; they contain a notation for the determination of pitch. Among the works ascribed to the *Banu Musa*, is one on the balance.

Islamic Geography, and Geology

Al-Ma'mun ordered geodetic measurements, to determine the size of the earth, and the drawing of a large map of the world. The mathematician **Al-Khwarizmi** wrote a geographical treatise, entitled the Face of the Earth, which was essentially revised edition of Ptolemy's geography; it included maps. *Sulaiman* the Merchant traveled to the coast-lands of the Indian Ocean and to China; an account of his journeys was published in 851.

Some idea of Muslim views on minerals may be obtained in the so called "Lapidary" of Aristotle. That compilation is probably of Syriac and Persian origin, and one may tentatively place the Arabic version in the first half of the ninth century. 'Utarid's lapidary, the earliest work of its kind in Arabic, dates probably from the same time.

Large map of the world
(which **Al-Ma'mun** ordered to be drawn)

Arabic Medicine

There is nothing to report in this time on either Latin or Chinese medicine, and that my account of Byzantine medicine is restricted to a reference to Leon of Thessalonica. Practically all the medical work of this period was due either to Japanese or to Arabic-speaking physicians. To consider the latter first, I said advisedly "Arabic speaking" and not "Muslim," because out of the eight physicians whom G. Sarton mentioned as the most important, six were Christians, most probably Nistorians. Of the two remaining, one was a true Arab, the other a Persian. A great part of the activity of these men was devoted to translating Greek medical texts, especially those of Hippocrates and Galen, into Syriac and into Arabic. All of these translators were Christians, the most prominent being ***Ya'hya ibn Batriq***, ***Ibn Sahda***, ***Salmawaih ibn Bunan***, ***Ibn Masawaih***, *and* ***Ayyub al-Ruhawi***.

Jibril ibn Bakhtyashu' collected Greek manuscripts and patronized the translators, but he also wrote some medical works. **Salmawaih ibn Bunan** showed that the use of aphrodisiacs, always so popular in the East, was dangerous. The greatest of all these physicians was the Christian **Ibn Masawaih** (Mesue Major). He dissected apes and composed various anatomical and medical writings, notably the earliest ophthalmological treatise extant in Arabic and a collection of aphorisms. The philosopher **Al-Kindi** wrote medical works also, the most important being one wherein he tried to establish posology on a mathematical basis. The Persian 'Ai al-Tabari completed, in 850, a medical encyclopaedia entitled Paradise of Wisdom**.**

Ibn Sahda

Flourished at al-Karkh (a suburb of Baghdad), probably about the beginning of the ninth century. Translator of medical works from Greek into Syriac and Arabic. According to the Fihrist he translated some works of Hippocrates into Arabic. According to **Hunain ibn Ishaq**, he translated the "De sectis" and the "De pulsibus ad tirones" of Galen into Syriac.
Max Meyerhof: New Light on Hunain ibn Ishaq (Isis, VIII, 704, 1926).

Jabril Ibn Bakhtyshu

Grandson of Jirjis ibn JibriI, q. v., second half of eighth century; physician to **Ja'far** the Barmakide, then in 805-6 to **Harun al-Rashid** and later to **Al-Ma'mun**; died in 828-29; buried in the monastery of St. Sergios in Madain (Ctesiphon). Christian (Nestorian) physician, who wrote various medical works and exerted much influence upon the progress of science in Baghdad. He was the most prominent member of the famous Bakhtyashu' family. He took pains to obtain Greek medical manuscripts and patronized the translators.
F. Wustenfeld: Arabische Aerzte (15-16, l840). L. Leclere: Medecine arabe (vol. 1, 99-102, 1876). M. Meyerhof: New Light on Hunain (Isls, VIII, 717, 1926).

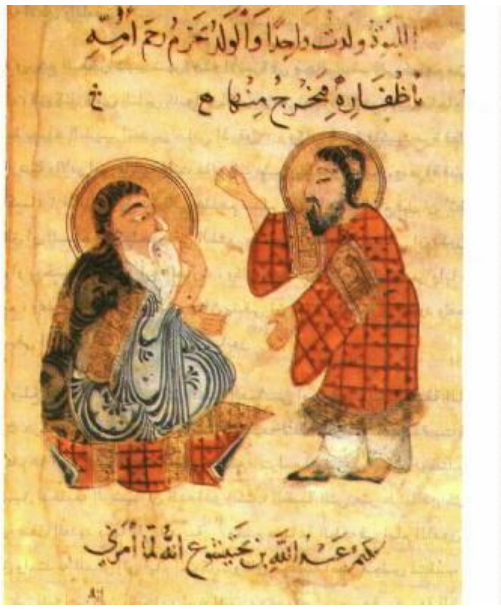
Salmawaih Ibn Buan

Christian (Nestorian) physician, who flourished under **Al-Ma'mun** and **Al-Mu'tasim** and became physician in ordinary to the latter. He died at the end of 839 or the beginning of 840. He helped Hunain to translate Galen's Methodus medendi and later he patronized Hunain's activity. He and **Ibn Masawaih** were scientific rivals. Salmanwaih realized the perniciousness of aphrodisiacs.
Leclerc: Medecine arabe (vol. 1, ll8, 1876). M. Meyerhof: New Light on Hunain (Isis, VIII, 71S, 1926).

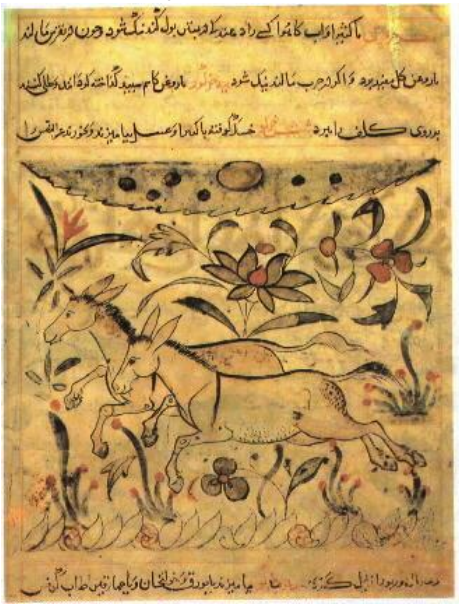
Ibn Masawaih

Latin name: Mesue, or, more specifically, Mesue Major; Mesue the Elder. Abu Zakariya Yuhanna ibn Masawaih (or Msuya). Son of a pharmacist in Jundishapur; came to Baghdad and studied under Jibrll ibn Bakhtyashu'; died in Samarra in 857. Christian physician writing in Syriac and Arabic. Teacher of **Hunain ibn Ishaq**. His own medical writings were in Arabic, but he translated various Greek medical works into Syriac. Apes were supplied to him for dissection by the caliph **Al-Mu'tasim** c. 836. Many anatomical and medical writings are credited to him, notably the "Disorder of the Eye" ("Daghal al-ain"), which is the earliest Systematic treatise on ophthalmology extant in Arabic and the Aphorisms, the Latin translation of which was very popular in the Middle Ages.

Text and Translation Aphorismi Johannis Damnseeni (Bologna, 1489. Translation of the al-nawadir al-tibbiya). Many other editions. In the early editions of this and other works, Joannes [Janus] Damascenu is named as the author.



*Picture of **Gibril Ibn Bakhtyshu***
with one of his patients 453 H./1061C.



Persian Copy of Mansucript named as
"Manaeh Al-Hiwan" by Ibn Bakhtyshu or Uses of Animals
in the 8 th century

The Time of **Al-Razi**
Second Half of Ninth Century

The whole ninth century was essentially a Muslim century. This more clear in the second half than of the first, since all the scientific leaders were Muslims, or at any rate were working with and for Muslims and wrote in Arabic.

Cultural Background

Abbasid Caliph **Al-Mutawakkil** (847-861) continued to protect men of science, chiefly the physicians, and he encouraged the school of translators headed by **Hunain ibn Ishaq**.
Da ud al-Zahiri founded a new school of theology, based upon a more literal interpretation of the Qur'an; however, did not survive very long. Muslim published a new collection of traditions, arranged according to legal topics, like **Bukhari**'s, but more theoretical.
The Egyptian **Dhul-Nun** is generally considered the founder of Sufism, that is, of Muslim mysticism.

Arabic Mathematics and Astronomy

G. Sarton clarify that when he said "Arabic" instead "Muslim" he means that some of the most important work accomplished under Muslim tutelage was actually done by non-Muslims but in Arabic language.
There were so many mathematical and astronomers in Islam that is necessary to divide them into four groups as he did before: geometers; arithmeticians; astronomers and trigometricians; astrologers.

Geometers: **Al-Mahani** wrote commentaries on Euclid and Archimedes, and tried to vain and divide a sphere into two segments, being in a given ratio. Archimedian problem became a classical Muslim problem; it led to a cubic equation which was called al-Mahani's equation. Hilal al-Himsi translated the first four books of Apolloinos into Arabic.

Ahmed ibn Yusuf wrote a book on proportions which are of special importance, because through it Western mathematicians became acquainted with the theorem of Menelaos. **Al-Nairizi** wrote commentaries on **Ptolemy** and **Euclid**.

Thabit ibn Qurra made very remarkable measurements of parabolas and paraboids, but is best known as the leader of a school of translators which produced Arabic versions of some of the mathematical classics: **Euclid**, **Archimedes**, **Apollonios**, **Theodosios**, **Ptolemy**, Thabit himself was the foremost translator and revised some of the translations made by others. The two most important translators of his school, outside of himself, were **Yusuf Al-Khuri** and **Ishaq ibn Hunain**. A comparison of this brief account with the similar section in the previous chapter will show that much progress had already been made in geometry since the beginning of the century.

Arithmeticians: I mentioned in the previous chapter the writings of **Al-Kindi** and **Al-Khwarizmi** were in probability the main channels through which the Hindu numerals known in Islam and later in the West. The earliest Muslim documents bearing such numerals date from 874 and 888. The propagation of these numerals may have been accelerated by the fact that the Muslim trade was exceedingly active in those

very days and reached every part of the world.
Thabit ibn Qurra developed the theory of amicable numbers. **Qusta ibn Luqa** translated Diophantos.

Astronomers and Trigonometricians: **Al-Mahani** made a series of astronomical observations from 855 to 866. **Al-Nairizi** compiled astronomical tables and wrote an elaborate treatise on the spherical astrolabe; he made systemic use of the tangent. **Hamid ibn Ali** became famous as a constructor of astrolabes. **Thabit ibn Qurra** published solar observations; he tried to improve the Ptolematic theory in planetary motions by the addition of a ninth sphere to account for the (imaginary) trepidation of the equinoxes. **Qusta ibn Luqa** wrote a treatise on the spherical astrolabes. **Jabir ibn Sinan**, of whom we know nothing, but who may have been al-Battani's father, constructed astronomical instruments, notably a spherical astrolabe.

The greatest astronomer of the age and one of the greatest of Islam was **Al-Battani** (Albategnius). He made a number of observations from 877, on, compiled a catalogue of stars for the year 880, determined various astronomical coefficients with great accuracy, discovered the motion of the solar apsides, and made an elaborate astronomical treatise which remained authoritative until the Sixteen Century. That treatise included naturally a trigonometical summary wherein not only sines, but tangents and cotangents, are regularly used. It contains a table of contangents by degrees and theorem equivalent to our formula giving the cosine of a side of a spherical triangle in function of the cosine of the opposite angle and of the sines and cosines of the other side.
Astrologers: The most famous astrologers were **Abu Bakr** (Albubather), **Ahmed ibn Yusuf**, and **Ibn Qutaiba**.
The whole mathematical and astronomical work was far more original than in the first half of the century and on a relatively high level. It is true, **Thabit ibn Qurra** introduced an unfortunate error of which a great many later astronomers (including Copernicus!) remained prisoners, but original research always implies the possibility of error. Thabit's error was no discreditable. The elaboration of trigonometry was continued with great skill and originality. Much attention was paid to astronomical instruments and especially to a new one, the spherical astrolabe, al-Battani's masterly work was a fitting climax to this wonderful activity.
So much for Islam. What was being done at the same time at the rest of the World? Nothing.

Muslim Alchemy and Physics

Al-Jahiz seems to have some chemical knowledge, for instance, he knew how to obtain ammonia from animal offals by dry distillation, but it would be absurd to call him a chemist. On the other hand, the great physician **Al-Rhazi** was undoubtedly a genuine chemist: he wrote various chemical treatises, described a number of chemical instruments, attempted to classify mineral substances, and even tried to apply his chemical knowledge to medical purposes. He may be considered a distant ancestor of the iatrochemists of the Sixteenth Century. He was also a physicist; he used the hydrostatic balance to make investigations on specific gravity. The mathematician al-Nairizi wrote a treatise on atmospheric phenomena.

Muslim Biology

The Muslims had little interest in natural history; they were certainly not tempted to study it for its own sake, but many of their current views on biological subjects may be found in their literary and historical compilations. The most remarkable example is “The Book of Plants” composed by the historian **Al-Dinawari**. The purpose of that book was primarily philological, but contains much valuable information for the historian of botany. **Al-Jahiz**’s “Book of Animals” is also a mine of information though most of it is folkloric rather than zoological.

Muslim Medicine

So much medical work was accomplished in Islam that is expedient to divide the physicians into two groups: those who were primarily practitioners and those who were primarily scholars and those who were engaged in translating the Greek medical classics into Syriac and Arabic. Of course, those of the second group were, all of them were for foreigners, non Muslims,; but even in the first group, one-half of the physicians was christians. thus the activity was christian rather than Muslim, but we must not forget that by far the greatest of all of them, **Al-Razi**, was a Muslim.
The Persian **Al-Razi** was simply the greatest clinician of Islam and of the whole middle ages; he was also, as we have seen, a chemist and physicist. It would be difficult to choose between him and his contemporary **Al-Battani**: both were very great scientist who would have been conspicuous in any age. I decide to call this period “The Time of **al-Razi**” because the physician is known to the larger public than the astronomer, and also because his influence can be traced more directly throughout many centuries of human effort, East and West. I have already remarked that **al-Razi** might be considered to be one of the forerunners of the iatrochemists of the Renaissance. He wrote an immense medical encyclopaedia called Al-hawi (“Continens”) and a monograph on measles and smallpox which is the masterpiece of Muslim medicine. **Ya’qub ibn akhi Hizam** was the author of a treatise on horsemanship, which contains some rudiments of veterinary art, the earliest work of its kind in Arabic.
The greatest of the translators was **Hunain ibn Ishaq** (Joannitius). He collected great medical manuscripts, translated many of them, supervised the activities of other scholars, and revised their translations. His role as regard to medical literature was very similar to that of Thabit ibn Qurra with regard to the mathematical and astronomical texts. The school of nestorian translators beaded by Hunain must have been quite considerable, for between them they managed to translate the greatest part of the Hippocratic and Galenic writings into Syriac and into Arabic. Hunain wrote also original works, notably a treatise on ophthalmology and the introduction to Galen’s Ars parva which was immensely medical writings: Hunain’s son Ishaq, Hubaish ibn al-Hassan, Isa ibn Yahia, Stephen son of Basil, Musa ibn Khalid, Thabit ibn Qurra, Yusuf al-Khuri. Hunain was a very great man, but he was more of a scholar than a scientist proper and his activity, which already had begun in the middle of the previous period, ended in the middle of this one; in other words **Al-Razi** and **Al-Battani** were one generation ahead of him. The time of Hunain, extending from 826 to 877, falls just between that of **Al-Khawarizimi** and that of al-Razi.

AL-MAHANI
Abu Abdallah Mohammed ibn Isa al-Mahani, that is, from Mahana, Kirman, Persia. Flourished c. 860, died c. 874 to 884. Mathematician, astronomer. A series of observations of lunar and solar eclipses and

planetary conjunctions, made by him from 853 to 866, was used by Ibn Yunus. He wrote commentaries on Euclid and Archimedes, and improved Ishaq ibn Hunain's translation of Menelaos's spherics. He tried vainly to solve an Archimedian problem: to divide a sphere by means of a plane into two segments being in a given ratio. That problem led to a cubic equation, $x^3 + c^2 b = cx^2$, which Muslim writers called al-Mahani's equation.

H. Suter: Die Mathematiker und Astronomen der Araber (26, 1900. His failure to solve the Archimedian problem is quoted by 'Omar al-Khayyami'). See Fr. Woepcke: L'algebra d'Omar Alkhayyami (2, 96 sq., Paris, 1851).

AHMED IBN YUSUF

Abu Ja'far Ahmed ibn Yusuf ibn Ibrahim al-Daya al Misri, i.e., the Egyptian. Flourished in Egypt in the second half and died about the Third Century H., c. 912. Mathematician. Secretary of the Tulunids, who ruled in Egypt from 868 to 905. He wrote a book on similar arcs (De Similibus arcubus), commentary on Ptolemy's Centiloquium, and a book on proportions ("De proportione et Proportionalitate"). The latter book is important because it influenced mediaeval thought through **Leonardo de Pisa** and **Jordanus Nemorarius** (theorem of Menelaos about the triangle cut by a transversal; al-qatta, sector; hence figura cata, regula catta).

M. Cantor: Ahmed und sein Buch Uber die Proportionen (Bibliotheca Mathematica, 7-9, 1888).

AL-NAIRIZI

Latin name: Anaritius. Abu-l-Abbas al-Fadl ibn Hatim al-Nairizi (i.e., from Nairiz, near Shiraz). Flourished under **Al-Mu'tadid**, Caliph from 892 to 902, died c. 922. Astronomer, Mathematician. He compiled astronomical tables and wrote for al-Mu'tadid a book on atmospheric phenomena, He wrote commentaries on **Ptolemy** and **Euclid**. The latter were translated by Gherardo da Cermona. Al-Nairizi used the so-called umbra (versa), the equivalent to the tangent, as a genuine trigonometric line (but he was anticipated in this by Habash, q. v., first half of ninth century). He wrote a treatise on he spherical astrolabe, which is very elaborate and seems to be the best Arabic work on the subject. It is divided into four books: (1) Historical and critical introduction; (2) Description of the spherical astrolabe; its superiority over plane astrolabes and all other astronomical instruments; (3 and 4) Applications.

H. Suter: Die Mathematiker und Astronomen der Araber (45, 1900); Nachtrage (164, 1902).

THABIT IBN QURRA

Abu Hassan Thabit ibn Qurra Marawan al-Harrani, that is, from Harran, Mesopotamia, born 826-27 (or 835-36), flourished in Bagdad, died in 901. Harranian physician, astronomer, mathematician. one of the greatest translators from Greek and Syriac into Arabic; the founder of a school of translators, in which many of his own family we remembers. apollonios (Books 5 to 7), Archimedes, Euclid, Theodosios, Ptolemy (geography), Galen, Eutocios were translated by him or under his direction, or translations made by others (e.g., **Ishaq ibn Hunain**) were revised by him. He published solar observations, explaining his methods. to the eight Ptolemaic spheres he added a ninth one (primum mobile) to account for the imaginary trepidation of the equinoxes (he is chiefly responsible for the introduction of this erroneous theory). His mensurations of parabolas and paraboloids are very remarkable. He improved the theory of amicable numbers (if $p = 3.2^n - 1$; $q = 3.2^{n-1}-1$; $r = 9.2^{2n-1}-1$; and if p, q, and r are prime together, 2^npq and 2^nr are amicable numbers). Many mathematical, astronomical, also anatomical and medical, writings are ascribed to him (most of them in Arabic, some in Syriac).

Fihrist (272, and comment. by index). F. Wustenfled: Geschichte der arabischen Aerzte (34-36, 1840. Followed by notices on other members of the same family).

YUSUF AL-KHURI
Joseph the Priest. Also called Yusuf al-Qass (same meaning) or al-Sahir (the vigilant). He was still living under the caliphate of al-Muqtafi (902 to 908). Physician and mathematician. Translator from Syriac into Arabic. He translated Archimedes's lost work on the triangles and Galen's "De simlicium temperamentis et facultatibus." That the first translation was revised by **Sinan ibn Thabit ibn Qurra** (q. v., first half of first century), the second by Ishaq.
H. Suter: Die Mathematiker der Araber (52, 224, 1900). Max Meyerhof: NewLight on Hunain ibn Ishaq (Isis, VIII, 704, 1926).

HAMID IBN ALI
Abu-l-Rabi Hamid ibn Ali al-Wasiti. From Waist in Lower Mesopotamia. Flourished in the ninth century, probably toward the end. Muslim astronomer. According to Ibn Yunus, Ali ibn Isa and Hamid were the foremost constructors of astrolabes. Ibn Yunus compares them to **Ptolemy** and **Galen**! This proves the importance which Muslims attached to good instruments.
H. Suter: Mathematiker (40, 1900).

MUSLIM (OR ARABIC) MEDICINE

SABUR IBN SAHL
Flourished at Jundishapur. Died Dec. 3, 860. Christian physician. He wrote an antidotary (Aqrabadhin), divided into 22 books, which was possibly the earliest of its kind to influence Muslim medicine, and other medical works. This antidotary enjoyed much popularity until it was superseded Ibn al-Tilmidh's new one (q. v., first half of twelfth century).
F. Wustenfled: arabische Aerzte (25, 1840).

YAHYA IBN SARAFYUN
Separion the elder. Yahya ibn Sarafyun. Flourished in Damascus in the second half of the ninth century. Christian physician who wrote in Syriac two medical compilations (Kunnash, pandects), one in 12 books, the other in 7 books. the latter was translated into Arabic by various writers and into Latin by Gherardo da Cermona (Practica sive breviarium). It was very popular during the middle ages. Its last book deals with antidotes. Ibn Srarfyun attached great importance to venesection and gave subtle prescriptions concerning the choice of the veins to be opened.
Fihrist (29; 303,1. 3; and comm. 296, note 1). Wustenfeld: Geschichte der arabischen Aerzte (49, 1840).

AL-RAZI
In Latin: Rhazes. Abu Bakr Mohammed ibn Zakaria al Razi. Born in Ray, near Tehran, Persia, about the middle of the ninth century. Flourished in Ray and in Bagdad. died 923-24. Physician, physicist, alchemist. The greatest clinician of Islam and middle ages. Galenic in theory, he combined with his immense learning true Hippocratic wisdom. His chemical knowledge was applied by him to medicine; he might be considered an ancestor of the iatrochemists. Of his many writings, the most important are the "Kitab al Hawi" (Continens), an enormous encyclopaedia containing many extracts from Greek and Hindu authors and also observations of his own; the "Kitab al Mansuri" (Liber Almansoris), a smaller compilation in ten books based largely on Greek science, and finally his famous monograph on smallpox and measles "Kitab al-jadari wal-hasba" (De variolis et morbiliis; de peste, de pestilentia), the oldest description of variola and the masterpiece of Muslim medicine. many contributions to gynaecology, obstetrics, and ophthalmic surgery can be traced back to him.

He made investigations on specific gravity by means of the hydrostatic balance, which he called al-mizan al-tabi'i. Various chemical treatises are ascribed to him, and one of them (Arcandorum liber, apocryphal?) contains a list of 25 pieces of chemical apparatus. He also made an attempt to classify chemical substracts.
The al-Hawi has not been published, and there is not even a single complete manuscript in existence. A latin translation, Liber dictus Elhavi, appeared in Brescia (1486), followed by various Ventian editions. The liber ad Almansurem, in ten books was first published in Milano (1481) and was frequently republished.

HUNAIN IBN ISHAQ

In Latin, Joannitius. Abu Zaid Hunain ibn Ishaq al-Ibadi. Born in Hira, 809-10. Flourished at Jundishapur, then in Baghdad, where he died in October 877. Famous Nestorian physician; one of the greatest scholars and of the noblest men of his tome. Pupil of Ibn Masawiah. Employed by the Banu Musa to collect Greek manuscripts and translate them into Arabic, he became the foremost translator of medical works. These translations were made partly with the assistance of other scholars.
It is reported that the Abbasid caliph **Al-Mutawakkil** created (or endowed) a school where translations were made under Hunain's supervision.

It is not too much to say that the translations made by Hunain and his disciplines marked a considerable progress in the history of scholarship. He took infinite pains to obtain manuscripts of the Greek medical texts; he collated them, examined the existing Syriac and Arabic versions, and translated them as accurately and as well as possible. His methods remind one of modern methods. to appreciate more the value of his efforts, one must realize that the Syriac versions were very unsatisfactory and the Arabic versions already available were hardly better. Hunain carefully compared these versions with the great text to prepare his new arabic translations. His activity was prodigious; it began as early as c.826 and lasted till the end of his days.

It is typical of Hunain scientific honesty that he very severely criticized the translations made by himself early in life. As his experience increased, his scientific ideal became more exacting. He translated a great many of **Galen**'s works, also various writings of **Hippocrates**, **Plato**, **Aristotle**, **Dioscordies**, and **Ptolemy**'s Quadripartitum. The importance of his activity can be measured in another way by stating that the translations prepared by Hunain and his school were the foundation of that Muslim canon of Knowledge which dominated medical thought almost to modern times.

Various medical and astronomical writings are ascribed to him (e. g., on the tides, on meteors, on the rainbow). His most Important work is his introduction to **Galen**'s "Ars prava" ("Isagoge Johannitii ad Tegni Galeni") which was mensly popular during the Middle Ages and played the same part in the teaching of medicine as Porphyry's "Isagoge" in that of logic. Galenic classification extended and elaborated.
Fihrist (294 f and by index). Ferdinand Wustenfeld: Geschichte der arabischen Aerzte und Naturforscher.

QUSTA IBN LUQA

Qusta ibn Luqa al-Ba'labakki, i. e. from Baalbek or Heliopolis, Syria. Flourished in Bagdad, died in Armenia about the end of the third century H., i. e., c. 912. A Christian of Greek origin. Philosopher, Physician, mathematician, astronomer, Translations of **Diophantos**, **Theodosios**, **Autolycos**, **Hypsicles**,

Aristarchos, Heron were made or revised by him, or made under his direction, He wrote commentaries on **Euclid** and a treatise on the spherical astrolabe.
Fihrist (295 and by index). C. Brockelmann : Geschichte der arabischen Litteratur (Vol. I, 204-205, 512, 1898).

JABIR IBN SINAN

Jaber ibn Sinan al-Harrani is one of the makers of astronomical instruments mentioned in the Fihrist at the end of the mathematical section. Nothing else is said of him, but **Al-Battani**'s full name suggests that this Jaber may have been his father. According to **Al-Biruni**, this Jaber was the first to make a spherical astrolabe.
Fihrist (p. 284). Sutre's translation (p. 41). H. Suter : Die Mathematiker (68, 224, 1900).

AL-BATTANI

In Latin: Albategnius, Albatenius. The origin of that nisba is unknown. Abu Abdallah Mohammed ibn Jabir ibn Sinan al-Battani, al-Harrani, al-Sabi, born before 858 in or near Harran. Flourished at al-Raqqa, in the Euphrates, died in 929 near Samarra. Of Sabin origin, though himself a Muslim. The greatest astronomer of his race and time and one of the greatest of Islam. Various astrological writings, including a commentary on Ptolemy's "Tetrabiblon" are ascribed to him, but his main work is an astronomical treatise with tables ("De scientia stellarum," " De numeris stellarum et motibus") which was extremely influential until the Renaissance. He made astronomical observations of remarkable range and accuracy from 877 on. His tables contain a catalogue of fixed stars for the years 880-81 (not 911-12). He found that the longitude of the sun's apogee had increased by $16^{0}47'$ increase since Ptolemy, that implied the discovery the motion of the solar apsides and of a slow variation in the equation of time. He determined many astronomical coefficients with great accuracy: precession 54.5" a year; inclination of the ecliptic, $23^{0}35'$. He did not believe in the trepidation of the equinoxes. (Copernicus believed in it!)
The third chapter of his astronomy is devoted to trigonometry. He used sines regularly with a clear consciousness of their superiority over the Greek chords. He completed the introduction of the functions umbra extensa and umbera versa (hence our contangents and tangents) and gave a table of contangents be degrees. He knew the relation between the sides and angles of a spherical triangle which we express by the formula

$$\cos a = \cos c \cos c + \sin b \sin c \cos A.$$

H. Suter : Die Mathematiker und Astronomen der Araber (45-47, 1900).

ABU BAKR

In Latin: Albubather. Abu Bakr al-Hassan ibn al-Khasib. Of Persian origin. Flourished probably in the third quarter of the ninth century. astrologer who wrote in Persian and arabic and would hardly deserve to be quoted but for the importance given to him in the middle ages. The work he is best known by ("De nativitatibus") was translated into Latin by one canonicus Salio in Padua 1218; it was also translated into Hebrew.
Fihrist (p. 276 and Commentary, p. 131). H. Suter : Die Mathematiker und Astronomen der Araber (32, 1900); Nachtrage (162, 1902); encycl. of Islam, II, 274, 1916.

The Time of **Al-Mas'udi**

First Half of Tenth Century

The overwhelming superiority of Muslim culture continued to be felt throughout the tenth century. Indeed, it was felt more strongly than over, not only the foremost men of science were Muslims, but also because cultural influences are essentially cumulative. By the beginning, or at any rate by the middle of the century, the excellence of muslim science was already so well established, even in the West, that each new arabic work benefited to some extent by the prestige pertaining to all. To be sure, other languages, such as Latin, Greek, or Hebrew were also used by scholars, but the works written in those languages contained nothing new, and in the field of science, as in any other, when one ceases to go forward, one already begins to go backward. All the new discoveries and the new thoughts were published in arabic. strangely enough, the language of the Qur'an had thus become the international vehicle of scientific progress.

The development of Muslim culture was fostere in Spain by the eighth Umayyad caliph of the west, **Abd Al-Rahman II**, the advances of Muslim science continued to take place almost extensively in the east.

Muslim Mathematics and Astronomy

Practically all the writings of this period were arabic. Let us consider these Arabic writings first. The mathematical production of this period was less abundant and on whole less brilliant than that of the previous one, but it was, for the first time exclusively Muslim, and there were at least two very distinguished mathematicians, **Abu Kamil** and **Ibrahim ibn Sinan**. **Ibn al-Adami** and **Ibn Amajur** compiled astronomical tables; the latter was said to be one of the best Muslim observers; he made a number of observations between 885 and 933, being aided by his son Ali and a slave called Moflih. **Abu Kamil** perfected **Al-Khwarizmi**'s algebra; he made a special study of the pentagon and decagon and of the addition and subtraction of radicals; he could determine and construct the two (real) roots of a quadratic equation. **Abu Othman** translated Book X of Euclid, together with Pappos's commentary upon it. Al-Balkhi and the physician **Sinan ibn Thabit** wrote various treatises on mathematical, astronomical, and astrological subjects. Al-Hamdani compiled astronomical tables for Yemen, and his great work on archaeology of his country contains much information on the scientific views of the early Arabs. **Ibrahim ibn Sinan** was primarily a geometer; he wrote commentaries on Apollonios and on Almagest and his determination of the area of a parabola was one of the greatest achievements of Muslim mathematics. **Al-Imrani** wrote astrological treatise and a commentary on Abu Kamil's algebra.

Muslim Physics and Alchemy

Ibn Wahshiya who will be dealt with more fully below, was primarily an alchemist and an occultist. His works do not seem to have any chemical importance, but they may help to understand alchemical symbolism.

Muslim Medicine

The newer medical ideas were, all of them, published in Arabic, but not necessarily by Muslims. The greatest physician of the age was a Jew, **Ishaq al-Isra'ili** (Isaac Judaeus). We owe him, for instance, the

main mediaeval treatise on urine.
Two of the Muslim mathematicians dealt with above, **Abu Othman** and **Sinan ibn Thabit**, became famous as organizers of hospitals; Sinan took pains to raise the scientific standards of the medical profession; **Abu Othman** translated Galenic writings into Arabic.

Muslim Mathematicians

IBN AL-ADAMI

Mohammed ibnal-Husain ibn Hamid. Flourished at the end of the ninth century or the beginning of the tenth. Muslim astronomer. He compiled astronomical tables which were completed after his death by his pupil **Al-Qasim ibn Mohammed ibn Hisham Al-Madani**. They appeared in 920-21 under the title Nazm al-iqd (Arrangement of the Pearl Necklace"), together with a theoretical introduction (lost!).
H. Suter: Mathematiker (44, 1920).

IBN AMAJUR

Abul-Qasim Abdallah Ibn Amajur (or Majur?) al-Turki. He originated from Fargana, Turkestan, and flourished c. 885-933. Muslim astronomer. One of the greatest observers among the Muslims. He made many observations between 885 and 933, together with his son **Abu-Hasan Ali** and emancipated slave of the latter, named Muflih. Father and son are often called Banu Amajur. Some of their observations are recorded by Ibn Yunus. Together they produced many astronomical tables: the Pure (alkhalis), the Girdled (al-Muzannar), the Wonderful (al-badi), tables of Mars according to Persian chronology, etc.
H. Suter: Mathematiker (49, 211, 1900; 165, 1902).

ABU KAMIL

Abu Kamil Shuja ibn Aslam ibn Mohammed ibn Shuja al-hasib al-Misri, i. e., the Egyptian calculator. He originated from Egypt and flourished after al-Khwarizmi, he died c. 850, and before al-Imrani, who died 955. We place him tentatively about the beginning of the tenth century. Mathematician. He perfected al-Khawarizimi's work on algebra. Determination and construction of both roots of quadratic equations. Multiplication and division of algebraic quantities. Addition and subtraction of radicals (corresponding to our formula

$$(a) \pm (b) = [\, a + b \pm (2ab) \,]\,).$$

Study of the pentagon and decagon (algebraic treatment). His work was largely used by al-Kakhi and Leonardo de Pisa.
H. Suter: Die Mathematiker und Astronomen der Araber (43, 1900; Nachtrage, 164, 1902).

ABU OTHMAN

Abu Othman Sa'id ibn Ya'qub al-Dimashqi, (i. e., the Damascene). Flourished at Bagdad under al-Muqtadir, Khalifa from 908 to 932. Muslim physician and mathematician. He translated into Arabic works of **Aristotle**, **Euclid**, **Galen** (on temperaments and on the pulse), and **porphyry**. His most important translation was that of Book X of Euclid, together with Pappos's commentary on it which is extant only in Arabic. The supervision of hospitals in Bagdad, Mekka, and Medina was intrusted to him in 915.
L. Leclerc: Medicine arabe (vol. 1, 374, 1876. Only a few lines). H. Suter: Die Mathematiker und Astronomen der Araber (49, 211, 1900).

AL-BALKHI

Abu Zaid Ahmed ibn Sahl al-Balkhi. Born in Shamistiyan, province of Balkh, died in 934. Geographer, mathematician. A member of the Imamiya sect; disciple of **Al-Kindi**. Of the many books ascribed to him in the Fihrist, I quote: the excellency of mathematics; on certitude in astrology. His "Figures of the Climates" (Suwar al-aqalim) consisted chiefly of geographical maps.
The "Book of the Creation and History" formerly ascribed to him was really written in 966 by Mutahhar ibn Tahir al-Maqdisi (q. v., next chapter).
M. J. de Goeje: Die Istakhri-Balkhi Frage (Z. d. deutschen morgenl. Ges., vol. 25, 42-58, 1871). H. Suter: Die Mathematiker und Astronomen der Araber (211, 1900).

IBRAHIM IBN SINAN

Abu Ishaq Ibrahim ibn Sinan ibn Thabit ibn Qurra. Born in 908-9, died in 946. Grandson of **Thabit ibn Qurra** (q. v. second half of ninth century); his father Sinan, who embraced Islam and died in 943, was also a distinguished astronomer and mathematician (see medical section below). Muslim mathematician and astronomer. He wrote commentaries on the first book of "Conics" and on the "Almagest", and many papers on geometrical and astronomical subjects (for example, on sundials). His Quadrature of the parabola was much simpler than that of Archimedes, in fact the simplest ever made before the invention of the integral calculus.
H. Suter: Die Mathematiker und Astronomen der Araber (53, 1900).

Al-IMRANI

Ali ibn Ahmed al-Imrani. Born at Mosul in Upper Mesopotamia; he flourished there and died in 955056. Muslim mathematician and astrologer. He wrote a commentary on **Abu Kamil**'s algebra and various astrological treatises. One of these, on the choosing of (Auspicious) days, was translated by Savasodra at Barcelona in 1131 or 1134 (De electiobus) (q. v. first half of twelfth century).
H. Suter: Mathematiker (56, 1900; 165, 1902).

Muslim Agriculture

IBN WAHSHIYA

Abu Bakr Ahmed (or Mohammed) ibn Ali ibn al-Wahshiya al-Kaldani or al-Nabati. Born in Iraq of a Nabataean family, flourished about the end of the third century H., i. e., before 912. Alchemist. Author of alchemistic and occult writings (quoted in the Fihrist). He wrote c. 904 the so-called "Nabataean agriculture" (Kitab al-falaha al-nabatiya), an alleged translation from ancient Babylonain sources, the purpose of which was to extol the Babylonian-Aramean-Syrian civilization (or more simply the "old" civilization before the hegira) against that of the conquering Arabs. It contains valuable information on agriculture and superstitions.

This forgery became famous because the great Russian orientalist Khvolson was entirely deceived by it. Of course, Ibn Wahshiya was as unable to read the cuneiform texts as the Egyptian Arabs the hieroglyphic.
Fihrist (311-312, 358).

ISHAQ AL-ISRA'ILI

Isaac Judaeus. Isaac Israeli the elder. (Not to be mistaken for the Spanish astronomer Isaac Israeli the younger; q. v., first half of fourteenth century.) Isaac ibn Solomon. Abu Ya'qub Ishaq ibn Sulaiman al-Isra'ili. Born in Egypt; flourished in Qairawan, Tunis, where he died, a centenarian, about the middle of the tenth century (c. 932?). A Jewish physician and philosopher, he was one of the first to direct the attention of the Jews to Greek science and philosophy. He was a physician to the Fatimid caliph "Ubaid Allah al-Mahdi" (909 to 934).

At Al-Mahdi's request Al-Isra'ili composed many medical writings in Arabic. These were translated into Latin in 1087 by Constantine the African, into Hebrew, and into Spanish. They were very influential works. The main medical writings are: on fevers (Kitab al-Hummayat); the book of simple drugs and nutriments (Kitab al-adwiya al-mufrada wal-aghdhiya; diaetae universales et particulares); on urine (Kitab al-Baul, by far the most elaborate mediaeval treatise on the subject); on deontology, the "Guide of the physician" (lost in Arabic, extant in Hebrew under the title of Manhag (or Musarha-rofe'im). Al-Isra'ili also wrote a medico-philosophical treatise on the elements (Kitab al-istiqsat), and another on definitions. Isaac Al-Isra'ili was the earliest Jewish philosopher (or one of the earliest) to publish a classification of the sciences. This was essentially the Aristotelian one as transmitted and modified by the Muslims.

Wustenfeld: Geschichte der arabischen Aerzte (51-52, 1840).

The Time of **Abu-l-Wafa**

Second Half of Tenth Century

The period, which we have just tried to analyze, and then to reconstruct, was on the whole one of comparative rest. There was no retrogression, but the advance of mankind, which had been so vigorously accelerated during the ninth century through the youthful energy of Islam, was then distinctly slowed up. It is not the first time that we thus witness a momentary quieting down of human activity; on the contrary, we have already had occasion to observe many such periods of fallow. e. g., the first half of the second century B. C., the second half of the fifth, the second half of the sixth, the second half of the seventh, the first half of the eighth. But in each case the slowing up was followed by a new acceleration. In other words, when we study the creative activity of the mankind as a whole, we find that humanity behaves very much as an individual man would do, that period of unusual achievements are generally followed by depressions, and periods of rest and fallow by new efforts.

The intellectual progress of mankind would not be correctly represented by a constantly increasing function, but rather by a sort of sinusoidal curve moving steadily upward. But how do we account for human tiredness, considering that the burden is periodically taken up by new generations? Leaving out of the question political and other external factors, which must necessarily influence human energy, we may explain the periodical slowing up in two ways. In the first place, the original flame of enthusiasm, which stimulates intellectual advance, is bound to die out gradually unless new men of genius appear from time to time to keep it alive; of course, there are no means of predicting when and where such men will appear. In the second place, the very progress of knowledge is certain to fill the more conservative minds with a growing anxiety, and finally to determine an orthodox reaction. For example, in the first half of the tenth century an intellectual reaction was led, very successfully, by **Al-Ash'ari**. Mankind does not go forward as a united body; on the contrary, each advance has to be paid a protracted struggle between those who long for more light and those who are afraid of it. The latter are far more numerous than the former, but less intelligent, and thus bound to be beaten in the end, this accounts at once for the sinusoidal advance and its upward tendency, or, in other words, for the slowness, but also for the continuity of human progress.
To come back to the second half of the tenth century, we shall see presently that it was a period of renewed activity in almost every field; the partial fallowness of the first half of the century was thus amply rewarded by more abundant crops and mankind was able to make a few more leaps forward.

Cultural background: **Mohammed ibn Ahmed Al-Khwarizmi** wrote "The Key of the Sciences."

Muslim Mathematics and astronomy: All of the creative work was done in Islam. Muslim mathematicians were so numerous that, for the sake of clarity, I must divide them into three groups - arithmeticians, algebraists, and geometers; astronomers and trigonometricians; astrologers.

Arithmeticians, algebraists, and geometers**:** It is well to begin this section with a brief account of the progress of the Hindu numerals. By the middle of the tenth century a special form of them, the so called dust (ghubar) numerals, was already used in Muslim Spain. The eastern Arabic form was represented in an Egyptian grafitto, dated 960-61. Mutahhar ibn Taher wrote a number of 10 figures by their means. The earliest Latin example of these numerals is found in a manuscript written in 976 near Logrono, in the Christian part of Spain.

Abu Ja'far Al-Khazin wrote commentaries on the tenth book of **Euclid** and other works and solved al-Mahani's cubic equation. **Al-Shaghani** investigated the trisection of the angle. **Nazif ibn Yumn** translated the tenth book of **Euclid**. The great astronomer **Abu-l-Wafa** wrote commentaries on **Euclid**, **Diophantos**, and **Al-Khwarizmi**, arithmetical and geometrical treatises, and solved a number of geometrical and algebraical problems. **Abu-l-Fath** improved the Arabic translation of **Apollonios**'s Conics and commented upon the first five books**. Al-Kuhi** was especially interested in the Archimedian and Apollonian problems leading up to higher equations and discovered some elegant solutions. which he discussed. **Al-Sijzi** worked along the same lines; he made a special study of the intersections of conics and found a geometrical means of trisecting angles. **Al-Khujandi**, better known as an astronomer, proved that the sum of two cubic numbers can not be a cubic number. **Maslama ibn Ahmed** composed a commercial arithmetic and studied an amicable number. (This would confirm that he was acquainted to the writings of the Brethren of Purity, for these were very much interested in the theory of numbers - a natural consequence of their Neoplatonic tendencies.)

Astronomical and trigonometricians: At the very beginning of this period we meet one of the best Muslim astronomers: **Abd Al-Rahman Al-Sufi**, who compiled an illustrated catalogue of stars, based upon his own observations. **Ibn Al-A'lam** was also a famous observer and published astronomical tables. **Al-Shaghani** invented and constructed astronomical instruments. The Buwayhid rulers, especially **Sharaf al-dawla**, were deeply interested in astronomy; Sharaf built a new observatory in Bagdad. The instruments were probably made by al-Shaghani, and the great mathematician, **Al-Kuhi**, was the leader of the astronomers.
The foremost of the astronomers employed by Sharaf was the Persian **Abu-l-Wafa**. It is true he was once believed to be; he did not discover the variation of the moon, but he continued in a masterly way the elaboration of trigonometry. Taken all in all, the fame of Abu-l-Wafa is more solidly based upon his mathematical than upon his astronomical contributions, but I placed him here because, in those days, trigonometry was considered a branch of astronomy.
Al-Khujandi made astronomical observations in Ray. Abu Nasr improved the Arabic text of Menelaos's Spherics and dealt with trigonometrical subjects. **Maslama ibn Ahmed** edited and revised **Al-Khwarizmi**'s astronomical tables, and wrote a commentary on Ptolemy's Planisphere.

Astrologers: The main astrologers were **Al-Qabisi** in Syria and **Rabi ibn Zaid** in Spain; the latter was a Christian, Bishop of Cordova under al-Hakam II.

Muslim Alchemy and Technology

The earliest scientific treatise in modern Persian (hitherto the Muslim Persians had written in Arabic) happens to be one of the most chemical works written by a Muslim until that time. It is really a treatise on materia medica, but it contains abundant information upon the preparation and properties of mineral substances. It is obvious that its author; **Abu Mansour Muwaffak**, was unusually stepped in chemistry. More may be learned about the chemical knowledge of those days, in the Eastern Caliphate, in the encyclopaedic works dealt with in Section III.
As to the Muslim West, the medical treatise of **Abu-l-Qasim** contains also various items of chemical interest; it explains the preparation of drugs by sublimation and distillation. two important alchemic writings have been ascribed to **Maslama ibn Ahmed**, but they are possibly a little later.

Muslim Medicine

The subtitle of this section is a little misleading, for the many adjectives tend to be the fact that everything was done by the Muslims alone.
Muslim physicians were so numerous that it is necessary to divide them into groups, and the most expedient division is, this time, a regional one. Thus I shall deal successively with the physician who flourished in the Eastern Caliphate (reserving a separate place for one of them who wrote in Persian), in Egypt, in Spain, and in North Africa.
The first group is the most numerous, as we would expect it. **Ahmed al-Tabari** wrote a medical treatise called Hippocratic treatments. **Ali ibn Abbas** (Hally Abbas), who flourished a little later, was one of the greatest physicians of Islam. He compiled a medical encyclopedia, "The Royal Book", which was very valuable but superseded by Avicenna's Qanun. It contains a number of original observations, under the patronage of Adud-al-Dawla, a new hospital was established in Bagdad in 979. **Al-Husain ibn Ibrahim** improved the Arabic text of Dioscorides. **Abu Sahl Al-Masihi**, who was, as his name indicates, a Christian, wrote a number of medical treatises. He shares with al-Qumri the fame of having been one of the teacher of Avicenna, the prince of mediaeval physicians. It is even possible that one of Abu Sahl's treatises gave Avicenna the first idea of composing his Qanun.
Note that all of those were Persians, but all wrote, as far as we know, in Arabic. Another Persian, **Abu Masour Muwaffak**, had the idea of compiling a great medical treatise in Persian. That treatise dealt with materia medica and contains a general outline of pharmacological theory. Its intrinsic value is great, but it has also a considerable extrinsic importance, because it is the oldest prose work in modern Persian.
Two distinguished physicians of that time flourished in Egypt, **Al-Tamimi** and **Al-Baladi**. The former is chiefly known because of his medical guide (Murshid), the latter wrote a treatise on the hygiene of pregnancy and infancy.
Medical activity in Muslim Spain, was almost of the same level as that which obtained in the Eastern Caliphate; in some respects it was even superior. One of the most distinguished of the Spanish physicians, however, was not a Muslim, but a Jew, the great **Hasdia ibn Shaprut**. He translated Dioscorides into Arabic with the aid of the Greek monk Nicholas. **Arib ibn Sa'd** wrote a treatise on gynecology, obstetrics, and pediatrics. **Abu-lQasim** (Abulcasis) was the greatest Muslim surgeon; he exerted a very deep influence upon he development of the European surgery down to the Renaissance. **Ibn Juljul** wrote a commentary on Dioscorides and added a supplement to it, and he compiled a history of the Hispano-Muslim physicians of his time.
The last Muslim country to be considered, Tunis, nutured also a great physician, **Ibn Al-Jazzar** (Algizar), author of a medical vade-mecum which obtained considerable success throughout the Middle Ages.

Muslim Mathematics and Astronomy

MUTAHHAR IBN TAHIR

Mutahhar ibn Tahir al-Maqdisi (or al-Muqaddasi), i. e., the native or inhabitant of the Holy City. From Jerusalem, flourished in Bust, Sijistan, c. 966. Encylcopaedist. Author of the book of the Creation and of History (*Kitab al-bad'wal-tarikh*), a summary of the knowledge of his day based not simply on Muslim, but also on Iranian and jewish sources. He quoted as a curiosity a very large number, 4,320,000,000 (representing the duration of the world in years according to the Hindus), in Hindu or Devanagari

numerals.
Cl. Haurt: Leveritable auteur du Libre de la creation et de lhistoire (Journal Asiatique (9), vol. 18, 16-21, 1901. Concludind that Mutahhar was the author); Arabic literature (284, 291, London, 1903).

ABU JA'FAR AL-KHAZIN

Alkhazin means the treasurer or the librarian. Born in Khurasan, died between 961 and 971. Mathematician, astronomer. Author of a commentary on the Tenth book of **Euclid** and of other mathematical and astronomical writings. He solved by means of conic sections the cubic equation which had baffled al-Mahani's efforts, the so-called al-Mahani's equation (q. v., second half of the ninth century.)
Fihrist (p. 266, 282); Suter's translation (p. 17, 39).

NAZIF IBN YUMN

Nazif ibn Yumn (or Yaman?) al-Qass means the priest (particularly, the Christian priest). Flourished under the Buwayhid sultan Adud al-dawla; died c. 990. Mathematician and translator from Greek into Arabic. He thus translated the Tenth book of **Euclid**. *H. Suter: Mathematiker (68, 1900).*

ABU-L-FATH

Abu-l-Fath Mahmud ibn Mohammed ibn Qasim ibn Fadl al-Isfahani. From Ispahan, flourished probably c. 982. Persian mathematician. He gave a better Arabic edition of the Conics of Apollonios and commented on the first books.
The Conics had been translated a century before by **Hilal al-Himsi** (books 1-4) and **Thabit ibn Qurra** (books 5-7) (see second half of ninth century).
H. Suter: Die Mathematiker und Astronomen der Araber (98, 1900).

AL-KUHI

Abu Sahl Wijan (or Waijan) ibn Rustam al-Kuhi. Of Kuh, Tabaristan, flourished in Bagdad c. 988. Mathematician, astronomer. Many mathematical and astronomical writings are ascribed to him. He was the leader of the astronomers working in 988 at the observatory built of the Buwayhid Sharaf al-dawla. He devoted his attention to those Archimedian and Apollonian problems leading to equations of a higher degree than the second; He solved some of them and discussed the conditions of solvability. These investigations are among the best of Muslim geometry.
M. Steinschnieder: Lettere intorno ad Alcuhi a D. Bald. Boncompagni (Roma, 1863). Suter: Die Mathematiker und Astronomen der Araber (75-76, 1900).

AL-SIJZI

Abu Sa'id Ahmed ibn Mohammed ibn Abd al-Jalil al-Sijzi (short for al-Sijistani). Lived from c. 951 to c. 1024. Mathematician who made a special study of the intersections of conic sections and circles. He replaced the old kinematical trisection of an angle by a purely geometric solution (intersection of a circle and an equilateral hyperbola.)
Suter: Die Mathematiker und Astronomen der Araber (80-81, 224, 1900).

Abd Al-Rahman Al-Sufi

Abu-l-Husan Abd al-Rahman ibn Omar al-Fufi al-Razi. Born in Ray 903, died 986. One of the greatest Muslim astronomers. Friend and teacher of the Buwayhid sultan Adud al-dawla. His main work is the "Book of the Fixed Stars" illustrated with figures "Kitab al-kawakib al-thabita al-musawwar", one of the

three masterpieces of Muslim observational astronomy (the two others being due to Ibn Yunus, first half of the eleventh century, and Ulugh Beg, first half of the fifteenth century).
Fihrist (284). Suter: Die Mathematiker und Astronomen der Araber (62, 1900).

IBN AL-A'LAM

Abu-l-Qasim Ali ibn al-Husain al-Alawi, al-Sharif al-Hisaini. Flourished at the Buwayhid court under Adud al-dawla (q. v.,); died at Bagdad in 985. Muslim astronomer. The accuracy of his observations was praised; he compiled astronomical tables which obtained much favor during at least two centuries.
H. Suter: Die Mathematiker der Araber (62, 1900).

AL-SAGHANI

Abu Hamid Ahmed ibn Mohammed al-Saghani al-Asturlabi, i. e., the astrolabe maker of Saghan, near Merv, flourished in Bagdad, died 990. Mathematician, astronomer, inventor and maker of instruments. He worked in Sharaf al-dawla's observatory and, perhaps, constructed the instruments which were used there. Trisection of the angle.
Suter: Die Mathematiker und Astronomen der Araber (p. 65, 1900).

ABU-L-WAFA

Abu-l-Wafa Mohammed ibn Mohammed ibn Yahya ibn Isma'il ibn al-Abbas al-Buzjani. Born in Buzjan, Quhistan, in 940, flourished in Bagdad, where he died at 997 or 998. Astronomer and one of the greatest Muslim mathematicians. One of the last Arabic translators and commentators of Greek works. He wrote commentaries on **Euclid**, **Diophantos**, and **Al-Khwarizimi** (all lost); astronomical tables (zij al-wadih) of which we have possibly a later adaptation; a practical arithmetic; "the complete book" (Kitab al-kamil), probably a simplified version of the Almagest. The book of applied geometry (Kitab al handasa) is probably in its present form, the work of a disciple.
His astronomical knowledge was hardly superior to **Ptolemy**'s. He did not discover the variation, the third inequality of the moon. He simply spoke of the second eviction, the Ptolematic, essentially different from the variation discovered by Tycho Brahe.
Solution of the geometrical problems with one opening of the compass. Construction of a square equivalent to other squares. Regular polyhedra (based on Pappos). Approximative construction of regular heptagon (taking for its side half the side of the equilateral triangle inscribed in the same circle). Constructions of parabola by points. Geometrical solution of

$x^4 = a$ *and* $x^4 + ax^4 = b$.

Abu-l-Wafa contributed considerably to the development of trigonometry. He was probably the first to show the generality of the sine theorem relative to spherical triangles. He gave a new method for constructing sine tables, the value of sin 30' being correct to the eighth decimal place. He knew relations equivalent to ours for sin (a $\pm$ b) (though in an awkward form) and to

$2\sin^2 a/2 = 1 - \cos a$ $\qquad$ $\sin a = 2 \sin a/2 \cos a/2$.

He made a special study of the tangent; calculated a table of tangents; introduced the secant and cosecant; knew those simple relations between the sic trigonometric lines, which are now often used to define them.
Fihrist (I, 266, 283, Suter's translation, p. 39).

AL-KHUJANDI

Abu Muhamid Hamid ibn al-Khidr al-Khujandi. Of Khujanda, on the jax artes, or Sir Daria, Transoxania, died c. 1000. Astronomer, mathematicain. He made astronomical observations, including a determination of the obliquity of the ecliptic, in Ray in 994. He proved (impefectly) that the sum of two cubic numbers cannot be a cubic number> He may be the discoverer of the sine theorem relative to spherical triangles.

Suter : Die Mathematiker und Astronomen der Araber (74, 213, 1900).

ABU NASR

Abu Nasr Mansur ibn Ali ibn Iraq. Teacher of al-Bairuni; still active in 1007. Muslim mathematician and astronomer; one of three to whom the discovery of the sine theorem relative to spherical triangles is ascribed. He gave in 1007-8 an improved edition of Menelaos's Spherica. Various other writings on trigonometry are ascribed to him.

H. Suter : Die Mathematiker und Astronomen der Araber (81, 255, Leipzig, 1900).

MASLAMA IBN AHMED

Abu-l-Qasim Maslam ibn Ahmed al-Majriti. Of Madrid, flourished in Cordova, died in or before 1007. Astronomer, mathematician, occulist. The earliest Hispano-Muslim scientist of any importance. He edited and corrected the astronomical tables of **Al-Khwarizmi**, replacing the Persian by the Arabic chronology. He wrote a treatise on the astrolabe (translated into Latin by Joan. Hispalensis); a commentary on **Ptolemy**'s Planisphaerium translated by Rudolph of Bruges (q. v., first half of twelfth century); a commercial arithmetic (al-mu'amalat); a book on the generation of animals (?). He may have introduced into Spain the writings of the Prethren Purity, or else this was done later by one of his disciples, al-Karmani. He spoke of the erotic power of amicable numbers (220, 284). Two alchemic writings, the "Sage's step" (Rutbat al-hakim) and the "Aim of the Wise", (Ghayat al-hakim), are ascribed to him. The second is well known in the Latin translation made in 1252 by order of King Alfonso under the title *Picatrix*; the original Arabic text dates probably from the middle of the eleventh century.

Ibn Khaldun: Prolegmenes. F. Wustenfeld: Geschichte der arabischen Aerzte (61, 1840).

AL-QABISI

Abu-l-Saqr Abd al-Aziz ibn Uthman ibn Ali al-Qabisi. Pupil of al-Imrani (q. v. , first half of tenth century) in Mosul; after the latter's death in 955-56 he was patronized by the Hamdanid sultan Sayf al-dawla, who died in 966-67. Famous Muslim astrologer. His main writings are his introduction to the art of astrology (*al-madkhal ila sina'at (ahkam) al-nujum*) and treatise on the conjunctions of planets; both were translated into Latin by Joannes Hispalensis (first half of twelfth century). He, or his patron Sayf al-dawla, wrote a poem on the rainbow.

H. Suter : Die Mathematiker und Astronomen der Araber (60, 1900; Nachtrag, 165, 1902).

RABI IBN ZAID

Rabi ibn Zaid al-Usquf. Meaning the bishop (from the Greek). He was Bishop of Cordova and Elvira under al-Hakam II. Flourished at Cordova c. 961. Spanish Christian writing n Arabic. He coposed various astronological treatises and dedicated to Hakam II a calendar (*Kitab al-anwa', liber anoe*) entitled "The Division of times and the Good of bodies."

Suter : Mathematiker (96, 212, 1900).

Muslim Alchemy and Technology

See notes on Abu-l-Qasim

Muslim Medicine

AHMED AL-TABARI

Abu-l-Hasan Ahmed ibn Mohammed al-Tabari. Of Tabaristan; was physician to the Buwwayhid Rukn al-dawla, c. 970. Persian Physician. Author of compendium of medicine, called Hippocratic treatments, in ten books. Was it written in Persian or in Arabic? It is extant only in Arabic, *Kitab al-mu'alaja al-buqratiya.*
F. Wustenfeld: Arabschen Aerzte (56, 1840).

ALI IBN ABBAS

Ali ibn Abbas al-Majusi, that is, the Magian, which means that he, or his father was of the Zoroastrian faith. Latin name: Ali Abbas or Hall Abbas. Born in Ahwaz, southwestern Persia; flourished under thw Buwayhid Adud al-dawla; died in 994. One of the three greatest physicians of the Eastern Caliphate. He wrote for Adud aldawla a medical encyclopedia called "the Royal Book" (*Kitab al-Maliki*, Liber regius, regalis dispositio; also called *Kamil al-sana 'a al-tibbiya)*, which is more systematic and consice than Razi's Hawi, but more practical than Avicenna'a Qanun, by which it was superseded. The Maliki is divided into 20 discourses, of which the first half deal with theory and the other with the practice of medicine. the best parts of it are those devoted to dietetics and to materia medica. Rudimentary conception of the capillary system. Interesting clinical observations. Proof of the motions of the womb during parturition (the child does not come out; it is pushed out).
Wustenfeld: Geschichte der arabischen Aerzte (59, 1840).

AL-HUSAIN IBN IBRAHIM

Al Husain ibn Ibrahim ibn al-Hasan ibn Khurshid al-Tabari al-Natili. Flourished c. 900-91. Translator from Greek into Arabic. He dedicated, in 990-91, an improved translation of Dioscorides to the Prince Abu Ali al-Samjuri.
C. Brockelmann: Arabische Litteratur (189, 207).

AL-QUMRI

Abu Masur al-Hasan ibn Nuh al-Qumri. From Qum in Jibal. Flourished probably at Bagdad, about the end of the tenth century, and the begining of the eleventh. Muslim Physician. Teacher of Avicenna. He wrote a treatise on medicine, largely based upon **al-Razi**, called the book of life and death (*Kitab Ghina wa mana'*), divided into three parts (internal diseases, external diseases, fevers).
C. Brockelmann: Arabische Litteratur (vol. 1, 239, 1808).

ABU SAHL AL-MASIHI

Abu Sahl Isa ibn Yahya al-Masihi al-Jurjani, i. e., the Christian, from Jurjan, east of the Caspian Sea;

died at the age of fourty in 999-1000. Christian physician writing in Arabic. Teacher of Avicenna. He wrote an encyclopaedic treatise on medicine in a hundred chapters (*al-Kutub al-mi'a fi-l-sana'a al-tibbiya*), which is one of the earliest Arabic works of its kind and may have been in some respects the model of the Qanun. He wrote a various smaller treatises: on measles, on the plague, on the pulse, demonstration of God's wisdom as evidenced in the creation of man, etc.
C. Brockelmann: Arabische Litteratur (vol. 1, 138, 1898).

ABU MANSUR MUWAFFAK

Abu Mansur Muwaffak ibn Ali al-Harawi. Flourished in Herat under the Samanid prince Mansur I ibn Nuh, who ruled from 961 to 976. Persian pharmacologist. He was apparently the first to think of compiling a treatise on materia medica in Persian; he travelled extensively in Persia and India to obtain necessary information. He wrote between 968 and 977, the "Book of the Remedies" (Kitab al-abnyia 'an Haqa'iq al-adwiya), which is the oldest pose work in modern Persian. It deals with 585 remedies (of which 466 are derived from plants, 75 from minerals, 44 from animals), classified into four groups according to their action. Outline of a general pharmacological theory. Abu mansur distinguished between sodium carbonate (natrun) and potassium carbonate (qli); he had some knowledge abot arsenious oxide, cupric oxide, silicic acid, antimony; he knew the toxilogical effects of copper and lead compounds, the depilatory vertue of quicklime, the composition of plaster of Paris and its surgical use.
E. G. Browne: Arabian Medicine (92, Cambridge, 1921).

AL-TAMIMI

Abu Abdallah Muhammed ibn Ahmed ibn Sa'id al-Tamimi al-Muqaddasi (meaning, the native or the inhabitant of the Holly City). Born in Jerusalen; he moved, c. 970, to Egypt and was still living there in 980. Palastinian physician. He made pharmaceutical experiments and wrote various medical works, chiefly on materia medica. His main work is a guide (Murshid) on materia medica, which contains valuable information on plants, minerals, etc. *Kitab al-murshid ila jawahir al-aghdhiya wa quwa-lmufradat*; guide toward (the understanding of) the substances of food-stuffs and (of) the simple drugs.
C. Brockelmann: Arabische Litteratur (vol. 1, 237, 1898).

AL-BALADI

Ahmed ibn Mohammed ibn Yahya al-Baladi. Flourished in Egypt under the Wazir Ya'qub ibn Kils, who died in 990-91. Egyptian physician. Author of a treatise on the hygiene of pregnant women and the babies (*Kitab Tadbir al-habala wal-atfal*).
C. Brockelmann: Arabische Litteratur (vol. 1, 237, 1898).

HASDAI IBN SHAPRUT

Alias shaprut, Shafrut, Bashrut, Shaprot. Abu Yusuf Isaac ibn Izra. Born c. 915 at Jaen, Andalus; flourished at Cordova at the court of Abd al-Rahman III; died in 970 or 990 at Cordova. Hispano-Jewish physician, translator of Greek into Arabic, Patron of science. Physician to the caliph. He discovered a panacea called al-faruq (the best).
A manuscript of Dioscorides having been presented in 948-49 to Abd al-Rahman III by the emperor Constantinos VII, Hasdai undertook to translate it with the assistance of the Greek monk Nicholas. This monk had been sent to Cordova by the emperor upon the caliph's request, in 951.
He wrote a Hebrew letter to the King of the Khazars discribing Andalus. He was a great patron of jewish science and it was partly due to his initiative and activity that the intellectual center of Israel was finally

transfered from academies of Babylonia to Spain.
Article by Rabbi Meyer Kayserling in Jewish encyclopaedia, vol. 6, 248, 1904.

ARIB IBN SA'D

Arib ibn Sa'd al-Khatib (the secretary) al-Qurtubi. Flourished at Cordova at the court of Abd al-Rahman IIi and al-Hakim II, who died in 976. Hispano-Mislim historian and physician. Originally Christian. He wrote a chronicle of Muslim Spain and Afric some time between 961-976. This chronicle was extensively used by Ibn al-Idhari (q. v., second half of thirteenth century). He wrote also a treatise on gynaecology, hygiene of pregnant women and infants, and on obstetric (*Khalq al-janin*, Creation of the embryo, in 964-65), and a calender (*Kitab al-anwa'*).
C. Brockelmann: Arabische Litteratur (vol. 1, 236, 1898).

ABU-L-QASIM

Latin names: Abulcasis, Albucasis, Alsaharavius. Khalaf ibn Abbas al-Zahrawi, from Zahra, near Cordova, where he flourished and died c. 1013. The greatest Muslim surgeon. Physician to al-Hakam II (961 to 976). His great medical encyclopedia in 30 sections, *al-Tasrif* (Vade-mecum) contains interesting methods of preparing drugs by sublimation and distillation. but its most important part is the surgical, in three books, largely based upon Paulos Aegineta. Great importance attached to cauterization and styptics. Parts of the surgery are devoted to obstetrics and to the surgical treatment of the eyes, ears, and teeth. This work was illustrated with views of the surgical instruments. It was early translated into Latin (by Gherardo Cremonese), Provencal and Hebrew. Muslim prejudices against surgery stifled Abu-l-Qasim's fame in Islam, but in the Christian world his prestigue was soon immense.
Wustenfled: Geschichte der Arabischen Aerschen (p. 85, 1840).

IBN JULJUL

Abu Da'ud Suliman ibn Hasan ibn Juljul. Physician to the Spanish Umayyad Hisham II, Mu'aiyad billah, caliph from 976 to 1009. Hispano-Muslim physician. He wrote, at Cordova, in 982, a commentary on Dioscorides, and later a supplement to it, and a history of the physicians and philosophers of his time in Spain (*Ta'rikh al-atibba wal-falasifa*), often quoted by Ibn abi Usaibi'a (q. v., first half of the thirteenth century).
The aim of the commentary was to determine the drugs dealt with by Dioscorides; the supplement was a list of drugs not mentioned by Dioscorides. As to the origin of these Dioscoridian studies, see my notes on Hasidai ibn Shaprut. It would seem that Ibn Juljul and others assisted in the translation of Dioscorides into Arabic.
C. Brockelmann: Arabische Litteratur (t. 1, 237, 1898).

IBN AL-JAZZAR

In Latin: Algizar, AlJazirah. Abu Ja'far Ahmed ibn Ibrahim Ibn Abi Khalid Ibn alJazzar. Flourished in Qairawan, Tunis, died in 1009, being more than 80 years old. Physician. Pupil of Ishaq al-Isra'ili (q. v., first half of the tenth century). Of his many writings, the most important because of its enormous popularity, was his "Traveller's Provision" (*Zad al-Musafir*) which was translated into Latin by Constantinus Africanus, into Greek by Synesios, and into Hebrew - the titles of these translations being: *Viaticum pergrinantis*; *Zedat al-Derachim*. It contains remarkable descriptions of smallpox and measles. He wrote also on the coryza, on the cuases of plague in Egypt, etc.
C. Brockelmann: Arabische Litteratur (vol. 1, 238, 1898).

The Time of **Al-Biruni**
First Half of Eleventh Century

The great leaders were so many - **Ibn Yunus**, **Ibn al-Haitham**, **Al-Biruni**, **Ibn Sina**, **Ali ibn Isa**, **Al-Karkhi**, **Ibn Gabirol** (all Muslim except the last, who was Jewish) - that, for a moment at least, the historian is bewildered. Yet, however distinguished all of those men, and many others who will be named presently, two stand out head and shoulders above the others: **Al-Biruni** and **Ibn Sina** (Avicenna). It was chiefly because all of them that this period was one of such excellence and distinction. These two men, who by the way, knew one another, were extremely different. **Al-Biruni** represents the more adventurous and critical spirit, Ibn Sina the synthetic spirit, **Al-Biruni** was more of a discoverer, and in that respect he came nearer to the modern scientific ideal; **Ibn Sina** was essentially an organizer, an encyclopedist, a philosopher. Both, even the latter, were primarily men of science, and it would be difficult to choose between them but the accidental fact that al-Biruni's life covered more fully the present period and thus may be said to represent it more completely. **Ibn Sina** was only 20 at the beginning of the century, and his life was ultimately cut short in 1037. Al-Biruni's first important work appeared about 1000 and he lived until 1048. Thus his time of activity and the first half of the eleventh century are not identical periods, and we are fully justified (more fully so than in almost every short case) in calling it the Time of al-Biruni.

Muslim Mathematics and astronomy

It is almost like passing from the shade to the open sun and from a sleepy world into one tremendously active. For the sake of convenience, I divide Muslim mathematicians into three groups: those of the West, those of Egypt, who occupied, so to speak, an intermediate position, and those of the East. This is also a logical division, for though communications between the eastern and western ends of the Islam were frequent (there were a number of itinerant scholars to whom the universality of Islam seems to have been a continual provocation to move on from place to place), it is clear that local influences were felt more constantly and to greater advantage.

The greatest astronomer and trigonometrician of the time was **Ibn Yunus**, who lived in Cairo. Every thing considered, he was perhaps the greatest Muslim astronomer, and the Fatimid rules of Egypt gave him magnificent opportunities. Indeed, under the sixth Fatimid, al-Hakim, a sort of academy of science (Dar al-Hikma) had been established in Cairo, and, had been the case for the academy founded by **Al-Ma'mun** in Bagdad two centuries earlier, an observatory was an essential part of it. Ibn Yunus made excellent use of these exceptional facilities to measure more accurately the number of astronomical

constants and to compile improved tables named after his patron, the Hakemite tables. He contributed his share to the development of trigonometry, discovering new solutions of spherical problems and introducing the first of the prosthapheretical formulas. His colleague in al-Hakim's academy, **Ibn Al-Haitham**, better known as a physicist, was also a great astronomer and mathematician. He made a curious attempt to measure the height of the atmosphere on the basis of his knowledge and of the length of twilight. He solved al-Mahani's equation and the so-called Alhazen's problem by means of intersecting conics.

The mathematicians of the East were so numerous, and though they could boast no man comparable in his branch of learning to **Ibn Yunus**, their work was generally on a very high level and full of originality. Kushyar ibn Labban especially interested in trigonometry, he made a deeper study on the tangent function and compiled new astronomical tables which were sooner translated into Persian. He also wrote on astrology and arithmetic. **Ibn al-Husain** investigated the classical problems of the Greek geometry (for example, the duplication of the cube) and tried to solve them by purely geometrical means. **Abu-l-Jud** was also a geometer; he made a special study on the regular heptagon and enneagon and of those problems which can not be solved by means of ruler and compass alone; he tried to classify equations with reference to conic sections, he is one of the mathematicians who prepared the work of **Omar Al-Khayyam** in the following period. The greatest of them all, **Al-Karkhi** was chiefly an arithmatician and algebraist. He solved a number of Diophantine problems and invented a series of new one. His work contains many of the original features, but the most extra-ordinary of these is the systematic neglect of Hindu numerals. No numerals are used, the names of the numerals being written in full. It is as if **Al-Karkhi** had considered the use of Hindu numerals as vulgar and non-scientific. **Al-Nasawi** wrote a practical arithmetic in Persian and later translated it into Arabic. He explained the Hindu methods and applied them to difficult numerical problems; in these computations the sexagesimal fractions introduced by astronomical measurements were replaced by decimal fractions. **Ibn Tahir** wrote also arithmetical book of a practical nature; he showed how to solve the complicated inheritance problems entailed by the Muslim fondness for juridical niceties. To **Al-Biruni** we owe the best mediaeval account of Hindu numerals. He composed an astronomical encyclopedia and a general treatise on mathematics , astronomy, and astrology. He was deterred neither by formidable computations nor by the most difficult geometrical problems of his time, those called after him Albirunic problems. He introduced a simplified method of stereographic projection. As we would expect, the philosophical aspects of mathematics were more to **ibn Sina** than the more technical details. We already know that in spite of his encyclopedic activities **Ibn Sina** found time to carry on a number of astronomical observations and to improve the observational technique.

I named these Eastern mathematicians, as well as possible, in chronological order. This does not, perhaps, bring out with sufficient clearness the full complexity of their activities. In the first place, observe that, I did not mention a single astrologer; only one named in this section flourished not in the East, but in the orthodox Tunis, where there was much less freedom of thought. In the second place, if we leave out of account the astronomical work, which was determined by practical necessities, we find that there were two distinct streams of mathematical thought: the one theoretical represented by **Ibn Al-Husain**, **Abu-l-Jud**, and **Al-Karkhi**, the other, more practical, represented by **Al-Nasawi** and **Ibn Tahir**. **Al-Biruni** and **Ibn Sina** can not be included in that classification, for they were equally in the most abstruse and in the most practical questions; they had no contempt for humble means, for there are no small matters for great minds.

Muslim Physics, Chemistry and Technology

Contemporary accounts of Muslim achievements must be started with **Ibn al-Haitham**, who flourished in Cairo at the beginning of the century. He was not only the greatest Muslim physicist, but by all means the greatest of mediaeval times. His researches on geometrical and physiological optics were the most significant to occur between ancient times and the sixteenth century. His description of the eye and his explanation of vision were distinct improvements. Muslim scientists had developed a great interest in the determination of specific gravity. **Al-Biruni** continued that tradition and measured the density of 18 precious stones and metals with remarkable accuracy. He observed that the speed of light is incomparably greater than the of sound. **Ibn Sina** investigated all the fundamental questions of physics which could be formulated finite. His study of music was especially important and far ahead of the contemporary Latin work. He described the doubling with octave, the fourth and the fifth, and even with the third.
A college of **Ibn al-Haitham** in the Cairo academy, **Masawaih al-Mardini**, explained the preparation empyreumatic oils. **Ibn Sina** intertained original views on chemistry; he did not share the common belief of Muslim alchemists that the coloring or bronzing of metals affected their substance, he thought that the differences between metals were to deep to permit their transmutation. An important alchemical treatise was composed in 1034 by **Al-Kathi**.

Muslim or Arabic Medicine

There are so many that I must again divide them into three groups. Those of Spain, those of Egypt, and those of the East.

Spain: **Al-Karmani** has already been mentioned. He was at once a mathematician and a surgeon. Ibn al-Wafid composed a treatise on simple drugs, which is partly extant in Latin, and a treatise on Balneography. To these two Muslims may be added the Jew, **Ibn Janah**, who flourished in Saragossa and wrote there in Arabic, a book on simple remedies.

Egypt: Not less than four great Physician enjoyed the patronage of the Fatimid rulers of Egypt. **Masawaih al-Mardini** (Mesue the Younger) compiled a large dispensatory which was immensely popular in mediaeval Europe. For centuries it remained the standard work on the subject. Ammar was perhaps the most original oculist of Islam, but his work was superseded by that of the Eastern contemporary, **Ali ibn Isa**. The surgical part of Ammar's ophthalmologic treatise is particularly important. The third of these physicians, **Ibn al-Haitham** (Alhazen) has already been dealt with many times; he must be remembered her because of his studies in physiological optics. **Ali ibn Ridwan** wrote various commentaries on Greek medicine, of which the best known was one on Galen's Ars prava; he also wrote a treatise on hygiene with special reference to Egypt. It should be noted that Masawaih was a monophysite Christian; the others were Muslims.

East: The greatest physician of the time and one of the greatest of all times was **Ibn Sina** (Avicenna). His enormous medical encyclopedia, the Qanun (Canon), remained the supreme authority, not simply in Islam but also in Christendom, for some six centuries. It contained a number of original observations,

but its hold on the people was chiefly due to its systematic arrangement and its very dogmatism. **Ibn Sina** was not as great a physician as **Galen**, but he had very much the same intellectual qualities and defects and his ascendancy was largely based upon the same grounds. He had the advantage over **Galen** being able to take into account the vast experience of Muslim physicians.
Ibn al-Taiyib wrote commentaries on Greek medicine. **Abu Sa'id Ubaid Allah**, of the famous Bakhtyashu family, wrote treatise on love-sickness and discussed the philosophical terms used by physicians. **Ibn Butlan** compiled the so-called Tables of Health, a medical summary, divided into 15 vertical columns; he is perhaps the originator of that typical form of synopsis. Finally **Ali ibn Isa** (Jesu Haly) was the author of the most famous ophthalmologistical treatise written in Arabic, it is very remarkable that not than three of these physicians, that is more than half of them, were Christians living in Bagdad: **Ibn al-Taiyib**, **Abu Sa'id Ubaid Allah**, and **Ibn Butlan**. This testifies for the faithfulness of the Christian community of Bagdad and the toleration of the Muslim rulers. It should be added that the other physicians, i.e., the Muslims, were far more important.

Muslim Mathematics and Astronomy

Muslim Mathematics of the West

AL-KARMANI
Abu Hakam Amr (or Omar) ibn Abd al-Rahman ibn Ahmed ibn Ali al-Karmani (that is of Carmona). Born in Cordova, died in Saragossa. Spanish-Muslim mathematician and surgeon. Disciple of Maslam ibn Ahmed (q. v., second half of tenth century). It is he (or else the latter) who introduced the writings of the Brethren of Purity into Spain.
Suter: Die Mathematiker und Astronomen der Araber (105, 1900).

IBN AL-SAMH
Abu al-Qasim Asbagh ibn Mohammed ibn al-Samh. Flourished at Granada; died May 29, 1035, at the age of 56. Hispano-Muslim mathematician and astronomer. He wrote treatises on commercial arithmetic (*al-mu'amalat*), on two mental calculus (*hisab al-hawa'i*), on the nature of numbers, two on geometry, two on astrolabe, its use and construction. His main work seems to have been the compilation of astronomical tables, according to the Siddhanta method (for which see my notes on Mohammed ibn Ibrahim al-Fazari second half of eighth century), together with theoretical explanations (c. 1025).
H. Suter: Mathematiker (85, 1900; 168, 1902).

IBN ABI-L-RIJAL
In Latin, Abenragel (also Albohazen, Alboacen, which was more correct, for Abenragel was his father's name, rather than his own). Abu-l-Hasan Ali ibn Abi-l-Rijal al-Saibani al-Katib al-Maghribi. Born in Cordova or else where in Spain or in northern Africa, flourished in Tunis some time about 1016 to 1040, died after 1040. Muslim astrologer. His main work is the "distinguished book on horoscopes from the constellations" (*al-bari fi ahkam al-nujum*). It was translated by Judah ben Moses from Arabic into Castilian, then from Castilian into Latin by Aegidius de Tebaldis and Petrus de Regio. He wrote a physiognomic treatise on Naevi.
H. Suter: Die Mathematiker und Astronomen der Araber (100, 1900; Nachtrage, 172, 1902); encyclopedia of Islam (vol. 2, 356, 1916).

IBN AL-SAFFAR
Abu-l-Qasim Ahmed ibn Abdallah ibn Omar al-Ghafiqi, best known under the name of Ibn al-Saffar, meaning son of coppersmith. Flourished at Cordova, toward the end of his life he retired in Denia and died there in 1035. Hispano-Muslim mathematician and astronomer. He wrote a treatise on the astrolabe and compiled tables according to the Siddhanta method.
H. Suter: Mathematiker (86, 225, 1900; 169, 1902).

Muslim Mathematics of Egypt

IBN YUNUS
Abu Hasan Ali ibn abi Sa'id Abd al-Rahman ibn Ahmed ibn Yunus (or Ibn Yunus) al-Sadafi al-Misri. Died in Cairo, 1009 (not 1008). The date of his birth is unknown, but his father died in 958-59. Perhaps the greatest Muslim astronomer. A well equipped observatory in Cairo enabled him to prepare improved astronomical tables. Begun c. 990 by order of the Fatimid caliph al-Aziz (975-996), they were completed in 1007 under the latter's son al-Hakim (996-1020) and are called after him the Hakemite Tables (al-zij al-kabir al-Hakimi). They contain observations of eclipses and conjunctions, old and new, improved values of astronomical constants (inclination of the ecliptic, 23 ^{o} 35'; longitude of the sun's apogee, 86^{o} 10'; solar parallax reduced from 3' to 2'; precession, 51.2" a year, no allusion to trepidation) and accounts of the geodetic measurements carried on order by **Al-Ma'mun** (q. v., first half of ninth century.)
His contributions to trigonometry, though less important than those of Abu-l-Wafa; are considerable. He solved many problems of spherical astronomy by means of orthogonal projections. He introduced the first of those prosthapheretical formulae which were indispensable before the invention of the logarithms, namely, the equivalent of

$$\cos\alpha\cos\beta = 1/2\,[\cos(\alpha - \beta) + \cos(\alpha + \beta)].$$

Approximate value of $\sin 1^{o} = 1.8/3.9 \sin (9/8)^{o} + 2.16/3.15 \sin(15/16)^{o}$
Ibn Yunus's observatory was a part of Hall of Wisdom (Dar al-hikma, abode of wisdom) founded in Cairo by the Fatimids. This institution, which lasted from 1005 to the end Fatimid regime (1171), might be considered the second Muslim academy of science, the first being that founded by **Al-Ma'mun** in Bagdad almost two centuries earlier.
Suter: Encyclopaedia of Islam (vol. 2, 428, 1918).

IBN AL-HAITHAM
See notes in the physical section, below.

Muslim Mathematics of East

AL-BIRUNI
Abu-Raihan Mohammed ibn Ahmed al-Biruni. Born in Khwarizm (Khiva) in 973 sojourned a

considerable time in India; died in 1048, probably at Ghazna in Sijistan (Afghanistan). He was by birth a Persian and a Shi'ite; his religion was tempered with agonistic tendencies, but his national, anti-Arabic feelings remained very strong until the end. Traveler, mathematician, philosopher, astronomer, geographer, encyclopedist. One of the very greatest of Islam, and, all considered, one of the greatest of all times. His critical spirit, toleration, love of truth, and intellectual courage were almost without parallel in mediaeval times. He claimed that the phrase "Allah is omniscient" does not justify ignorance. He wrote, in Arabic, a number of books on geographical, mathematical, and astronomical subjects. His main works were: (1) the "Chronology of ancient nations" or "Vestige of the past" (*Kitab al-athar al-baqiya ani-l-qurun al-khaliya*), written in 1000 and dealing chiefly with the calendars and ears of various peoples; (2) an account on India (*Ta'rikh al-Hind*) composed in Ghazna c. 1030; (3) an astronomical encyclopedia, the Mas,udic canon (*al-qanon al-Mas'udi fi-l-hai'a wal-nujum*), so-called because it was dedicated in 1030 to the Ghaznawid sultan Mas'ud; (4) a summery on mathematics, astronomy, and astrology (*Al-tafhim li-awa'il sina'at al-tanjim*). His description of Brahmanical India was based upon a deep study of the country and its people. He had been charmed by Hindu philosophy, especially by the Bhagavadgita. He translated from Sinskrit into Arabic (e. g., two of Varahamihira's works, q. v., first half of sixth century), and on the other hand, transmitted Muslim knowledge to the Hindus.

He gave a clear account (the best mediaeval account) of Hindu numerals (principle of position). Sum a geometric progression apropos of the chess game; it led to the following number: $16^{16}-1$ = 18, 446, 744, 073, 709, 551, 916. Trisection of the angles and other problems which can not be solved with ruler and compass alone (Albirunic problems). Simplified stereographic projection, similar to that first published by G.B. Nicolosi di Paterno in 1600 (Isis, V, 498).

Accurate determination of latitudes. Determination of longitudes. Geodetic measurements. Al-Biruni discussed the question whether the earth rotates around its axis or not, without reaching a definite conclusion.

Investigations on specific gravity. Remarkably accurate determination of the specific density of 18 precious stones and metals. As compared to the speed of sound, that of light is immense. The work of natural springs and "artesian" wells is explained by the hydrostatic principle of communicating vessels. Description of monstrosities, including what we call "Siamese" twins.

The Indus valley must be considered as ancient sea basin filled up with alluvions.

H. Suter and E. Wiedemann: Uber al-Biruni (Erlangen, 1920. Quoted above). Carra de Vaux: Penseur de l'Islam (vol. 2, 1921, passim).

KUSHYAR IBN LABBAN

Abu-l-Hasan Kushayr ibn Labban ibn Bashahri al-Jili (i. e., from Jilan, south of the Caspian Sea). Flourished c. 971-1029; his main work was probably done about the beginning of the eleventh century. Persian mathematician and astronomer, writing in Arabic. He seems to have taken an important part in the elaboration of trigonometry. For example, he continued the investigations of **Abu-l-Wafa**, the devoted much space to this in his tables, al-zij al-jami wa-l-baligh (the comprehensive and mature tables), which were translated into Persian before the end of the century. He wrote also an astrological introduction and an arithmetic treatise (extant to Hebrew).

H. Suter: Mathematiker und Astronomen der Araber (83, 235, 1900; 168, 1902).

IBN AL-HUSAIN

Abu Ja'far Mohammed ibn al-Husain. Flourished not long after al-Khujandi (q. v., second half of the tenth century). Mathematician. He wrote a memoir on rational right angled triangles and another on the

determination of two mean proportionals between two lines by a geometrical method (vs. kinematic method), i. e., by the use of what the Muslims called “fixed geometry”, al-handasa al-thabit. Solution of the equation

$x^2 \pm a = y^2$.

Suter: Die Mathematiker und Astronomen der Araber (80, 1900; Nachtrage, 168, 1902).

ABU-L-JUD

Abu-l-Jud Mohammed ibn al-Lith, contemporary of al-Biruni. Mathematician. Solution of al-Birunic problems by means of intersecting conics. Regular heptagon and enneagon. Classification of equations and their reduction to conic sections.
Suter: Die Mathematiker und Astronomen der Araber (79, 1900).

AL-KARKHI

Abu Bakr Mohammed ibn al-Hassan (or Husain) al-Hasib (the calculator) al-Karkhi, meaning of Karkh, a suburb of Bagdad. Flourished in Bagdad during the vizierate of Abu Ghakib Mohammed ibn Khalaf Fakhr al-mulk (glory of the realm), who died in 1016; he died himself c. 1019 to 1029. One of the greatest Muslim mathematicians. His book on arithmetic (the sufficient on calculation, *alkafi fi-l-hisab*) is based chiefly of the Greek and Hellenistic knowledge. No numerals of any kind are used, the names of the numbers being written in full. Casting out of the nines and elevens.

If $r < (2a + 1)$, $[(a^2 + r)] \sim a + r/(2a + 1)$.

His algebra called (*al-fakhri*) in honor of the vizier is largely based on Diophantos. Complete solutions of quadratic equations (with proofs; two roots considered if positive and if not null). Reduction of equations of the type $ax2p + bxp = c$ to quadratic equations. Addition and subtraction of radicals. Summation of series. Solution of Diophantine equations (including 25 problems not found in Diophantos). Al-Karkhi’s neglect Hindu mathematics was such that it must have been systematic.
H. Suter: Encyclopaedia of Islam (vol. 2, 764, 1925. Very little).

AL-NASAWI

Abu-l-Hasan Ali ibn Ahmed al-Nasawi. From Nasa, Khurasan. Flourished under the Buwayhid sultan Majd al-dawla, who died in 1029-30, and under his successor. Persian mathematician. He wrote a practical arithmetic in Persian, before 1030, and later under Majd al-dawla’s successor an Arabic translation of it, entitled the “Satisfying (or Convincing) on Hindu Calculation” (*al-muqni fi-l-hisab al hindi*). He also wrote on Archemedes’s lemnata and Menelaos’s theorem (Kitab al-ishba, satiation). His arithmetic explains the division of fractions and the extraction of square and cubic roots (square root of 57,342; cubic root of 3, 652, 296) almost in the modern manner. It is remarkable that al-Nasawi replaces sexagesimal by decimal fractions, e. g.,
Suter: Die Mathematiker und Astronomen der Araber (96, 1900) Uber das Rechenbuch des Ali ben Ahmed el-Nasawi (Bibliotheca Mathematica, vol. 7, 113-119, 1906).

IBN AL-HAITHAM

Latin name: Alhazen. Abu Ali al-Hasan ibn al-Hasan (or al-Husain) ibn al-Haitham. Born c. 965 in Basra, flourished in egypt under al-Hakim (996 to 10200 died in Cairo in 1039 or soon after. The greatest Muslim physicist and one of the greatest students of optics of all the times. He was also an astronomer, a mathematician, a physician, and he wrote commentaries on **Aristotle** and **Galen**.
The Latin translation of his main work, the Optics (*kitab al-manazir*), exerted a great influence upon Western science (R. Bacon; Kepler). It showed a great progress in the experimental method. Research in catoptrics: spherical and parabolic mirrors, spherical aberration; in dioptrics: the ratio between the angle and incidence and refraction does not remain constant; magnifying power of a lens. study of atmospheric refraction. The twilight only ceases or begins when the sun is 19 ^{0}below the horizon; attempt to measure the height of the atmosphere on that basis. Better description of the eye, and better understanding of vision, though **ibn al-haitham** considered the lens as the sensitive part; the rays originate in the object seen, not in the eye. Attempt to explain binocular vision. Correct explanation of the apparent increase in the size the sun and the moon when near the horizon. earliest use of the camera obscura.
The catoptrics contain the following problem, known as Alhazen's problem: from two points of the plane of a circle to draw lines meeting at point of the circumference and making equal angles with the normal at that point. It leads to an equation of the fourth degree. Alhazen solved it by the aid of an hyberpola intersecting a circle. He also solved the so-called al-Mahani's (cubic) equation (q. v., second half of the ninth century) in a similar (Archimedian) manner.
Suter: Die Mathematiker und Astronomen der Araber (91-95, Nachtrage, 169, 1902).

AL-KATHI

Abu-l-Hakim Mohammed ibn Abd al-Malik al-Salihi al-Khwarizmi al-Kathi. Flourished in Bagdad c. 1034. Muslim Chemist, he wrote, in 1034, a treatise on alchemy entitled "Essence of the Art and Aid to the Workers" (*Ain al-san'a wa awn-al-sana'a*), strikingly similar in some respects to the "Summa perfectionis magisterii" of the Latin Geber (for which see my notes on Jabir, second half of eighth century).
H. E. Stapleton and R. F. Azo: Alchemical Equipments in the Eleventh century (Memories of Asiatic Society of Bengal, vol. 1, 47-70, 1 pl., Calcutta, 1905. Containing Arabic text, an analysis of it, and an introduction; very important).

Muslim (or Arabic) Medicine

Arabic-Writing physicians of the West

AL-KARMANI

See notes in mathematical section

IBN AL-WAFID

Latin name: Abenguefit. Abu-l- Mutarrif abd al-Rahman ibn Mohammed ibn Abd al-Karim ibn Yahya ibn al-Wafid al-Lakhmi. From Toledo, where he flourished; born 997, died c. 1074. Hispano-Muslim

physician, Pharmacologist. His main work, on simple drugs (*Kitab al-adwaiya al-mufrada*), based on Galen and Discorides and also on personal investigations, is partly extant in a Latin translation. He preferred to use dietetic measures, and, if drugs were needed, to use the simplest ones. He advised a method of investigating the action of the drugs. He also wrote a balneotherapy.
C. Brocklmann: Arabischen Litteratur (vol. 1, 485, 1898. Two Arabic manuscripts mentioned).

Arabic-Writing physicians of Egypt

MASAWIAH AL-MARDINI
Mesue the Younger. Masawaih al-Mardini, from Mardin in Upper Mesopotamia. Flourished in Bagdad, later at the court of the Fatimid caliph al-Hakim in Egypt, where he died in 1015 at the age of ninety. Physician. Jacobite Christian. He wrote book on purgatives and emetics (*De medicins laxativis*) and on the complete pharmacopoeia in 12 parts called the *Antidotarium sive Grabadin medicamentorum*, based on Muslim knowledge. The last-named work was immensely popular. It remained for centuries the standard text-book of pharmacy in the West, and Mesue was called “pharmacopoeorum evabgelista”. Distillation of empyreumatic oils.
There is still a third Mesue (q. v., first half of thirteenth century), author of a treatise on surgery.
Neuburger: Geschichte der Medizin (vol. 2, 226-227, 1911).

AMMAR
Latin name: Canamusali. Abu-l-Qasim Ammar ibn Ali al-Mawsili. From Mawsil in Iraq; flourished in Egypt in the reign of al-Hakim, who ruled from 996-1020. Physician. The most original of Muslim oculists, His work was eclipsed by that of his contemporary **Ali ibn Isa**, which was more comprehensive. His summary on the treatment of the eye (*Kitab al-muntakhab fi ilaz al-ain*) contains many clear descriptions of diseases and treatments, arranged in logical order. The surgical part is especially important.
E. Mittwoch: Encyclopaedia of Islam (vol. 1, 332, 1910).

IBN AL-HAITHAM
See notes in physical section, above.

ALI IBN RIDWAN
Abu-l-Hasan Ali ibn Radwan ibn Ali ibn Ja’far al-Misri. Born in Jiza near Cairo, c. 998. Flourished in Cairo and died there in 1061 or in 1067. Astrologer. physician. The author of many medical writings of which the most popular was his commentary on Galen’a Ars prava, which was translated by Gerardo Cremonese. I may still quote his treatise on hygiene with special reference to Egypt (*fi daf mudar al-abdan bi-ard Misr*). He wrote various other commentaries on Hippoctates and Galen and on Ptolemy’s astrological books.
C. Brocklmann: Arabischen Litteratur (vol. 1, 484, 1898).

Arabic-Writing physicians of the East

IBN SINA

Abu Ali al-Hassan ibn Abdallah ibn Sina. Hebrew, Aven Sina; Latin, Avicenna. Born in 980 at Afshana, near Bukhara, died in Hamadhan, 1037. Encyclopaedist, philosopher, physician, mathematician, astronomer. The most famous scientist of Islam and one of the most famous of all races, places, and times; one may say that his thought represents the climax of mediaeval philosophy. He wrote a many great treatises in prose and verse; most of them in Arabic, a few in Persian. His philosophical encyclopedia (*Kitab al-shifa, sanatio*) implies the following classification: theoretical knowledge (subdivided, with regard to increasing abstraction, into physics, mathematics, and metaphysics), practical knowledge (ethics, economy, politics). His philosophy roughly represents the Aristotelian tradition as modified by Neoplatonic influences and Muslim theology. Among his many other philosophical works, I must still quote a treatise on logic, *Kitab al-isharat wal-tanbihat* (The Book of Signs and Adonitions). As **ibn Sina** expressed his views on almost any subject very clearly, very forcible, and generally more than once, his thought is, or at any rate can be, known with great accuracy. His most important medical works are the Qanun (Canon) and a treatise on cardiac drugs (hitherto unpublished). The *Qanun fi-l-tibb* is an immense encyclopedia of medicine (of about a million words), a codification of the whole ancient and Muslim knowledge. Being similar in many respects to **Galen**, **Ibn Sina** elaborated to a degree the Galenic classifications (for example, he distinguished 15 qualities of pain). Because of its formal perfection as well as its intrinsic value, the *Qanun* superseded **Razi**'s Hawi, **Ali ibn Abbas**'s *Maliki*, and even works of **Galen**, and remained supreme for six centuries. However the very success of **Ibn Sina** as an encyclopedist caused his original observations to be correspondingly depreciated. Yet the *Qanun* contains many examples of good observation - distinction of mediastinitis from pleurisy; contagious nature of phthitis; distribution of diseases by soil and water; careful description of skin troubles, of sexual diseases; and supervisions; of nervous ailments (including love sickness); many psychological and pathological facts clearly analyzed if badly explained.

Ibn Sina's interest in mathematics was philosophical rather than technical and such as we would expect in a late Neoplatonist. He explained the casting out of nines and its application to the verification of square and cubes. Many of his writings were devoted to mathematical and astronomical subjects. He composed a translation on **Euclid**. He made astronomical observations, and devised a contrivance the purpose of which was similar to that of the vernier, that is, to increase the precision of instrumental readings.

He made a profound study of various physical questions - motion, contact, force, vacuum, infinity, light, and heat. He observed that if the perception of light is due to the emission of some sort of particles by the luminous source, and speed of light must be finite. He made investigations on specific gravity.

He did not believe the possibility of chemical transmutation, because in his opinion the differences of the metals were not superficial, but much deeper; coloring or bronzing the metals does not affect their essence. It should be noted that these views were radically opposed to those which were then generally accepted.

Ibn Sina's treatise on minerals was the main source of the geological ideas of the Christian encyclopedist of the thirteenth century.

Ibn Sina wrote an autobiography which was completed by his favorite disciple **Al-Juzajani**.

His triumph was too complete; it discouraged original investigations and sterilized intellectual life. Like **Aristotle** and **Vergil**, **Avicenna** was considered by the people of later times as a magician.

C. Brocklmann: Geschichte der arabischen Litteratur (vol. 1, 452-458, 1898. With list of 99 works).

IBN AL-TAIYIB

Abu-l-Faraj Abdallah Ibn al-Taiyib al-Iraqi. Latin name : Abulpharagius Abdalla Benattibus. Died in

1043-44. Nestorian physician. Secertary to Elias I, Nestorian Catholics from 1028 to 1049. Physician at the Adudite hospital in Bagdad. He had many commentaries on Greek medicine, and original memories on various medical topics, also a translation of the pseudo-Aristotelian *De plantis*, with additional excerpts from ancient literature.
From Arabic translation of the Diatessaron ascribed to him.
Brocklmann: Arabischen Litteratur (vol. 1, 482, 1898).

ABU SA'ID UBAID ALLAH

Abu Sa'id Ubaid Allah ibn Bakhtyashu. Flourished in Maiya-fariqin, Jazirah; friend of Ibn Butlan; died in 1058. Physician. The last and possibly the greatest representative of the Bukhtyashu, a syrian family of physicians which emigrated from Junsishapur to Bagdad in 765. His main works are the Reminder of the Homestayer, dealing with the philosophical terms used in medicine, and a treatise on lovesickness.
C. Brocklmann: Encyclopaedia of Islam (t. 1, 601, 1911).

IBN BUTLAN

Abu-l-Hasan al-Mukhtar ibn al-Hasan ibn Abdun ibn Sa'dun ibn Butlan. Latin name: Elluchasem Elimither. Flourished in Bagdad; died, probably in Antioch, in or soon after 1063. Christian physician. He wrote synoptic tables of hygiene, dietetics, domestic medicine, called the Tables of Health. He probably originated that form of synopsis, which was developed by ibn Jazla (q. v., second half of eleventh century). Medical polemic with Ali ibn Ridwan.
C. Brocklmann: Arabischen Litteratur (vol. 1, 483, 1898).

ALI IBN ISA

Ali ibn Isa or Jesu Haly. flourished in Bagdad in the first half of the eleventh century. He is said to have been a christian. The most Famous Arabic oculist. His "Manual" in three books, *Tadhkirat al-kahhalin*, is the oldest Arabic work on ophthalmology of which the original text is completely extant. It is based partly on ancient knowledge, partly on personal experience. It is at once very detailed and very comprehensive. The first book deals with the anatomy and physiology of the eye; the second with the diseases externally visible; the third with hidden diseases, dietetics, and general medicine from the oculistic standpoint; 130 eye diseases are carefully described; 143 drugs characterized.
J. Hirschberg: Die arabischen Lehrbucher der Augenheilkunde (Abhd. der preuss. Ak. der Wiss

The Time of **Omar Khayyam**
(Second Half Of Eleventh Century)

The most original creations of this time were made in the field of mathematics by Muslims, and the most original genius among those to whom we owe these creations was the Persian **Omar Khayyam**. It is thus very appropriate to call this time the Time of **Omar Khayyam**, as Omar is already very well known to a large number of readers. It is probable that his name is more familiar to them than that of any other Muslim scientist. It will thus be relatively easy to remember the title, and I trust that this remembrance will reach to some extent the contents of the following pages. The time of Omar Khayyam was the end of the golden age of Muslim science.

A new Muslim sect, that of the Assassins, an off-shoot of the Ismailiya movement, originated in Cairo about 1080.
They took possession of the fortress of Alamut, which remained their main stronghold for a century and a half. Alamut seems to have been also a center of learning.
The Muslim philosopher who has obtained the largest following in the West, in fact the only one who has become at all popular, is the persian poet and sufi Omar Khayyam. On the other hand, one of Omar's contemporaries, **Al-Ghazzali**, was the greatest theologian of Islam. He might be compared to **Thomas Aquinas**, to whom he was in many ways superior. **Al-Ghazzali** was also a Persian and spent part of his life in Omar's native place, Nishabur. While Omar Khayyam is the most popular fingure of mediaeval times, **Al-Ghazzali** is probably the noblest.

Muslim Mathematics and Astronomy

Important astronomical work was done at Cordova. **Ibn Said**, aided by other Muslim and Jewish astronomers, made a number of observations. These observations were used by **Al-Zarqaili** (Arzachel), for the compilation of new tables, the so-called Toledan tables, which obtained considerable authority in western Europe. **Al-Zarqaili** invented a new kind of astrolabe and proved the movement of the solar apogee; unfortunately, he confirmed the erroneous theory of the "trepidation" of the equinoxes. His tables were preceded, as usual, by an elaborate trigonometrical introduction.
The philosopher **Al-Ghazzali** wrote a treatise on the motion and nature of stars and an astronomical

summary; he had some knowledge of magic squares. The Bagdadite **Muhammad ibn Àbd al-Baqí** wrote a commentary on the tenth book of **Euclid**.
The activity of Muslim geographers, which had been so intense during the ninth and tenth centuries, abated during the present century. For the second half of this century two men will be recorded, one in the West and the other in the East. The western one, **Al-Bakri**, is of special importance, become the road-book which the compiled in the traditional manner is the oldest one of its kind due to a Spaniard. He also compiled a dictionary of ancient (i.e., Arabian) geography. The Eastern one is also a very arresting personality. **Nasir-I-Khusraw** was an Ismaili missionary who, starting from Egypt, traveled extensively in the Near East and as far east as Persia. He wrote in Persia an account of his travels, which is equally valuable from the geographical and from the historical point of view.
The contributions of Islam may seem small, but they were still of a very high quality.
In spite of Anselm, Psellos, and Constantine, in spite of the Chanson de Roland, in spite of Alfasi, Rashi, and Nathan, Islam was still at the vanguard of humanity. There was nowhere else in the world, in those days, a philosopher who could at all compare with **Al-Ghazzali**, neither an astronomer like **Al-Zarqali**, neither a mathematician like **Omar Khayyam**. These men were to towering far above their contemporaries.
If we proceed to examine more carefully the intellectual condition of Islam, we discover, in the first place, that some of the most important contributions were due to Persians; this was not novelty, but what is more starting, they were written in Persian.
Al-Ghazzali was the only Persian who wrote in Arabic; **Al-Hasan ibn al-Sabbah**, **Omar Khayyam**, **Nasir-I-Khusraw**, **Zarrin Dast**, **Nidham al-Mulk**, and **Asadi** wrote in Persian.
The city of the caliphs gave us still a number of scientists but none of great distinction - **Muhammad ibn Àbd al-Baqí**, **Ibn Jazla** (of Christian origin), **Sa'íd ibn hibat Allah**, **Al-Khatíb al-Baghdadí**, and **Al-Mawardí**. The only center of intellectual progress in Islam was Spain, but the heyday of Cordova was already over. Indeed, of the seven scientists and scholars who make us think of the Muslim Spain of those days with gratitude, only one can be connected with Cordova, the geographer **Al-Bakrí**.
The greatest of them all, **Al-Zarqali**, flourished in Toledo, and so did the original historian **Ibn Sa'íd**. Yusuf al-Mutamin lived in Saragossa; **Abu 'Umar ibn Hajjaj** in Seville. Ibn Sída, was born in Murcia and died in Denia.
But the development of astronomy by **Al-Zarqal** and of algebra by **Omar Khayyam** were definite steps forward.
A great orientalist went so far as to say : "The fourth century is the turning-point in the history of the spirit of Islam".

MUSLIM MATHEMATICS AND ASTRONOMY

AL-ZARQALI

In Latin : Arzachel. Abu Ishaq Ibrahim ibn Yahya al-Naqqash, the engraver. Better known as Ibn al-Zarqali. From Cordova, lived from c.1029 to c.1080. Astronomer. The best observer of his time (observations dated 1061, 1080).
He invented an improved astrolabe called safiham (saphaea Arzachelis); his description of it was translated into Latin, Hebrew, and many vernaculars. He was the first to prove explicitly the motion of the solar apogee with reference to the stars; according to his measurements it amounted to 12.04" per

year (the real value being 11.8").
On the other hand, comparing his observation of the obliquity of the ecliptic with previous ones, he concluded that it oscillated between 23o 33' and 23o 53', thus reenforcing the erroneous belief in the "trepidation" of the equinoxes. He edited the so-called Toledan Tables, planetary tables based upon the observations made by him and probably other Muslim and Jewish astronomers in Toledo (notably Ibn Sa'íd).
These tables were translated into Latin by Gherardo Cremonese and enjoyed much popularity. The trigonometrical introduction (*Canones sive regulae tabularum astronomiae*) was al- Zarqali's own work; it explains the construction of the trigonometrical tables.

YUSUF AL-MUTAMIN

Of the tribe of the Banu Hud; king of Saragossa from 1081 to 1085. His father, Ahmed al-Muqtadir Billah, king from 1046 to 1081, was also a student and a patron of students. Hispano-Muslim mathematician and patron of science.
He wrote a mathematical treatise, *Istikmal* (Bringing to perfection), of which it was said that it should be studied together with Euclid, the *Almagest*, and the "middle books."p
No copy of Yusuf's treatise is known; it is strange that a work believed to be so important and written by a king should be lost.
Stanley Lane Poole: *Mohammedan Dynasties* (26,1893)
H.Suter: *Mathematiker* (108,1900).

OMAR KHAYYAM

Abu-l-Fath 'Umar ibn Ibrahím al-khayyamí - the tentmaker - Ghiyath al-dín. Born in or near Níshabur c. 1038 to 1048, died there in 1123-24.
Persian mathematician, astronomer, and poet. One of the greatest mathematicians of mediaeval times. His *Algebra* contains geometric and algebraic solutions of equations of the second degree; an admirable classification of equations, including the cubic; a systematic attempt to solve them all, and partial geometric solutions of most of them (he did not consider negative roots and his failure to use both branches or halves of a conic caused him to miss sometimes one of the positive roots). His classification of equations is very different from our own; it is based on the complexity of the equations (the number of different terms which they include).
Of course the higher the degree of an equation the more different terms, or combinations of terms, it can contain. Thus Omar recognizes 13 different forms of cubic equation. (The modern classification based primarily upon the degree dates only from the end of the sixteenth and the beginning of the seventeenth century).
Binomial development when the exponent is a positive integer. Study of the postulates and generalities of Euclid.
In 1074-75 the saljuq sultan Malikshah, Jalal al-dín, called him to the new observatory of Ray (or Níshabur, or Isfahan?) to reform the old Persian calendar:
(30x12)d.+5d.=365 d. The latter had been temporarily replaced by the Muslim calendar after the conquest. Omar's calendar was called al-ta'rikh al-Jalal.
Its era was the 10th Ramadan 471=16 March 1079. There are many interpretations of Omar's reform and to each corresponds a certain degree of accuracy, but at any rate, Omar's calendar was very accurate, probably more so than the Gregorian calendar.

The correct interpretation is probably one of the three following, the second being the most probable of them. I quote for each, the authority, then the gist of the change, and finally the resulting error:
According to **Al-Shirazi** (d.1449), 15 intercalary days in 62 years; error, 1 day in about 3,770 years.
Moden interpretation, 8 intercalary days in 33 years; error, 1 day in about 5,000 years.
(The Gregorian calendar leads to an error of 1 day in 3,330 years).
Methods for the determination of specific gravity.
It is impossible not to mention the *Ruba'iyat* (quatrains) of Omar Khayyam, which have become, especially since 159 (when **Edward Fitzgerald** published the first instalment of his English paraphrase), one of the most popular classics of the world literature. Omar Khayyam was probably not a sufi, but rather an agnostic.
Comparisons of his thought with that of Lucretius and that of Voltaire are suggestive but indaequate.

MUHAMMAD IBN' ABD AL-BAQI

Abu Bakr(?) Muhammad ibn 'Abd al-Baghdadi. Flourished c. 1100.
Possibly the author of a commentary on the tenth book of Euclid, which was very popular because of its numerical applications. It is entitled "Liber judei super decimum Euclidis" in the translation by Gherardo Cremonese.

MUSLIM MEDICINE

IBN JAZIA

Abu 'ali Yahya ibn Isa Ibn Jazla. Latin forms: Bengesla, Buhahylyha, Byngezla, etc.
Flourished in Bagdad, died in 1100. Christian physician, who embraced Islam in 1074. His most important work is a medical synopsis, wherein 44 tables of two pages each contain the description and outline the treatment of 352 diseases (8 in each table); it was probably modeled upon similar work of Ibn Butlan (q .v; first half of eleventh century) and is called "Tables of the Bodies with regard to their constitutions" (Taqwim al-abdan fi tadbir al-insa; dispositio corporum de constitutions hominis). He wrote for al-Muqtadi (caliph from 1075 to 1094) an alphabetical list of simple and compound medicines called "The Pathway of Explanation as to that which Man Uses" (Minhaj al-bayan fi ma yasta 'miluhu al-insan; methodica dispositio eorum, quibus homo uti solet).

SA'ID IBN HIBAT ALLAH

Abu-I-Hassan Sa'id ibn Hibat Allah ibn al-Hasan. Flourished in Bagded under al-Muqtadi, caliph from 1075 to 1094, died in 1101-2. Physician and philosopher.
Author of a synopsis of medicine, *Al-mughni fi tadbir al-amrad wa ma 'rifat al-'ilal wal-a'rad* (Sufficiens de cura morborum et eognitione causarum et symptomarum) and of a treatise on physiology and psychology called "Discourse on the creation of Man", *Maqala fi khalq al-insan* (De constitutione hominis), dealing with such subjects as reproduction, gestation, parturition, growth, decay, survival of the soul, etc.

ZARRIN DAST

Abu Ruh Muhammad ibn Mansur ibn abi ‘Abdallah ibn Mansur al-Jamani (or al-Jurjani). Zarrin Dast means the Golden Hand, a good name for an eye surgeon.
Flourished under the Saljuq sultan Abu-l-Fath Malikshah ibn Muhammad, ruling from 1072-73 to 1092-93. Persian oculist. He completed in 1087-88, a very comprehensive and very remarkable treatise on ophthalmology entitled “The Light of the Eyes” (*Nur al-ayun*) (in Persian).
Hirschberg: *Geschichte der Augenheilkunde bei den Arabern* (57 sq., Leipzig, 1905).
Adolf Fonahn: *Quellenkunde der persischen Medizin* (38-41, 1910. Includes summary of the treatise, based upon Hirschberg).

Timeline of Islamic Scientists (700-1400)

This chart depicts the lifes of key Islamic Scientists and related writers, from the 8th to the end of the 13th century. By placing each writer in a historical context, this will help us understand the influences and borrowing of ideas**.**

701 (died) - **Khalid Ibn Yazeed** - Alchemy

721 - **Jabir Ibn Haiyan** (Geber) - (Great Muslim Alchemist)

740 - **Al-Asmai** - (Zoology, Botany, Animal Husbandry)

780 - **Al-Khwarizmi** (Algorizm) - (Mathematics, Astronomy)

787 - **Al Balkhi**, **Ja’Far Ibn Muhammas** (Albumasar) - Astronomy, Fortune-telling

796 (died) - **Al-Fazari**, **Ibrahim Ibn Habeeb** - Astronomy, Translation

800 - **Ibn Ishaq Al-Kindi** - (Alkindus) - (Philosophy, Physics, Optics)

808 - **Hunain Ibn Is’haq** - Medicine, Translator

815 - **Al-Dinawari**, **Abu-Hanifa Ahmed Ibn Dawood** - Mathematics, Linguistics

836 - **Thabit Ibn Qurrah** (Thebit) - (Astronomy, Mechanics)

838 - **Ali Ibn Rabban Al-Tabari** - (Medicine, Mathematics)

852 - **Al Battani ABU abdillah** (Albategni) - Mathematics, Astronomy, Engineering

857 - **Ibn MasawaihYou'hanna** - Medicine

858 - **Al-Battani** (Albategnius) - (Astronomy, mathematics)

860 - **Al-Farghani** (Al-Fraganus) - (Astronomy,Civil Engineering)

884 - **Al-Razi** (Rhazes) - (Medicine,Ophthalmology, Chemistry)

870 - **Al-Farabi** (Al-Pharabius) - (Sociology, Logic, Science, Music)

900 - (died) - **Abu Hamed Al-ustrulabi** - Astronomy

903 - **Al-Sufi** (Azophi - (Astronomy)

908 - **Thabit Ibn Qurrah** - Medicine, Engineering

912 (died) - **Al-Tamimi Muhammad Ibn Amyal** (Attmimi) - Alchemy

923 (died) - **Al-Nirizi**, **AlFadl Ibn Ahmed** (wronge Altibrizi) - Mathematics, Astronomy

930 - **Ibn Miskawayh**, **Ahmed Abuali** - Medicine, Alchemy

932 - **Ahmed Al-Tabari** - Medicine

936 - **Abu Al-Qasim Al-Zahravi** (Albucasis) - (Surgery, Medicine)

940 - **Muhammad Al-Buzjani** - (Mathematics, Astronomy, Geometry)

950 - **Al Majrett'ti Abu-alQasim** - Astronomy, Alchemy, Mathematics

960 (died) - **Ibn Wahshiyh**, **Abu Baker** - Alchemy, Botany

965 - **Ibn Al-Haitham** (Alhazen) - Physics, Optics, Mathematics)

973 - **Abu Raihan Al-Biruni** - (Astronomy, Mathematics)

976 - **Ibn Abil Ashath** - Medicine

980 - **Ibn Sina** (Avicenna) - (Medicine, Philosophy, Mathematics)

983 - **Ikhwan A-Safa** (Assafa) - (Group of Muslim Scientists)

1019 - **Al-Hasib Alkarji** - Mathematics

1029 - **Al-Zarqali** (Arzachel) - Astronomy (Invented Astrolabe)

1044 - **Omar Al-Khayyam** - (Mathematics, Poetry)

1060 - (died) **Ali Ibn Ridwan Abu'Hassan Ali** - Medicine

1077 - **Ibn Abi-Sadia Abul Qasim** - Medicine

1090 - **Ibn Zuhr** (Avenzoar) - Surgery, Medicine

1095 - **Ibn Bajah**, **Mohammed Ibn Yahya**

1097 - **Ibn Al-Baitar Diauddin** (Bitar) - Botany, Medicine, Pharmacology

1099 - **Al-Idrisi** (Dreses) - Geography, World Map (First Globe)

1091 - **Ibn Zuhr** (Avenzoar) - (Surgery, Medicine)

1095 - **Ibn Bajah**, **Mohammad Ibn Yahya** (Avenpace) - Philosophy, Medicine

1099 - **Al-Idrisi** (Dreses) - (Geography -World Map, First Globe)

1100 - **Ibn Tufayl Al-Qaysi** - Philosophy, Medicine

1120 - (died) - **Al-Tuhra-ee**, **Al-Husain Ibn Ali** - Alchemy, Poem

1128 - **Ibn Rushd** (Averroe's) - Philosophy, Medicine

1135 - **Ibn Maymun**, **Musa** (Maimonides) - Medicine, Philosphy

1140 - **Al-Badee Al-Ustralabi** - Astronomy, Mathematics

1155 (died) - **Abd Al Rahman Al-Khazin** - Astronomy

1162 - **Al Baghdadi**, **Abdellateef Muwaffaq** - Medicine, Geography

1165 - **Ibn A-Rumiyyah Abul'Abbas** (Annabati) - Botany

1173 - **Rasheed AlDeen Al-Suri** - Botany

1184 - **Al-Tifashi**, **Shihabud-Deen** (Attifashi) - Metallurgy, Stones

1201 - **Nasir Al-Din Al-Tusi** - (Astronomy, Non-Euclidean Geometry)

1203 - **Ibn Abi-Usaibi'ah**, **Muwaffaq Al-Din** - Medicine

1204 (died) - **Al-Bitruji** (Alpetragius) - (Astronomy)

1213 - **Ibn Al-Nafis Damishqui** - (Anatomy)

1236 - **Kutb Aldeen Al-Shirazi** - Astronomy, Geography

1248 (died) - **Ibn Al-Baitar** - (Pharmacy, Botany)

1258 - **Ibn Al-Banna** (Al Murrakishi), **Azdi** - Medicine, Mathematics

1262 (died) - **Al-Hassan Al-Murarakishi** - Mathematics, Astronomy, Geography

1273 - **Al-Fida** (Abdulfeda) - (Astronomy, Geography)

1306 - **Ibn Al-Shater Al Dimashqi** - Astronomy, Mathematics

1320 (died) - **Al Farisi Kamalud-deen Abul-Hassan** - Astronomy, Physics

1341 (died) - **Al-Jildaki**, **Muhammad Ibn Aidamer** - Alchemy

1351 - **Ibn Al-Majdi**, **Abu Abbas Ibn Tanbugha** - Mathematics, Astronomy

1359 - **Ibn Al-Magdi**, **Shihab-Udden Ibn Tanbugha** - Mathematic, Astronomy

History of Islamic Science
Based on the book
Introduction to the History of Scienceby George Sarton
(provided with photos and portraits)
Edited and prepared by Prof. Hamed A. Ead