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Middle Eastern Origins of Modern Sciences

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AS THE SAYING GOES, there is nothing new under the sun. Since time immemorial, human beings have inherited existing knowledge from previous generations, improved upon it by adapting it to their present needs, and transmitted it to future generations. Besides this vertical transmission, the transfer of knowledge also occurs horizontally from one place or culture to another by the continual exchange of ideas. Human civilization has been built over a period of about seven millennia with its beginnings along the banks of Shatt al-Arab, the Nile, and the Indus. Knowledge has been gathered through patient observation, experience, as well as serendipity. Prior to the Greco-Roman civilization, scholars of Khalidiah, Babylon, Phoenicia, Egypt, India, and China had greatly contributed to human understanding of the universe up to the seventh century BC. Greek learning progressed up to the second century BC, when it succumbed to the iron fist of Rome. The latter failed to encourage creativity, innovation and scientific investigation. During this time, Greek contributions lapsed into oblivion until they were discovered and improved upon for onward transmission by Muslims.

The responsibility of coordinating such exchanges falls, by default or by design, upon the contemporary dominant power(s). Since the sixteenth century, the West has greatly expanded its inheritance by coordinating, improving, and disseminating its knowledge. Its contribution to modern science and technology has remained unmatched and is likely to remain so for quite some time to come. Especially revolutionary and mind-boggling has been the digitization of data, images, and sound, as well as the miniaturization of tools such as wireless computer technology supported by space-based global positioning systems.

Unlike in other cultures, the social science tradition as developed in Europe has played down the similarities among various cultures and civilizations and exaggerated the dissimilarities for its own politico-economic reasons. One major reason for this practice was to conceal the contributions of the colonized nations to human civilization. Such a tendency helped perpetuate the notion of "the white man's burden to civilize the world" and thus exploit with impunity their natural and technological resources.

THE RATIONALE

One might ask why we should discuss the heyday of a nation left so far behind others in the march of scientific and technological progress. What good is it to keep harping on about our past laurels in the spirit of Pidaram sultan bood [My father was king]! without going into the causes for our miserable plight today? The answer is that there is more than one single reason for invoking our past.

The modern world is now experiencing three major trends: (1) revolution in the area of information technologies; (2) globalization; and (3) privatization. It is the first, especially the digitization of information, that has brought various peoples closer together to interact with one another in the global trade arena, and has allowed individuals access to information and knowledge (if not wisdom) in an unprecedented manner. Thus, these trends have made nations more interdependent. The increased interdependence is both enriching and troubling in that it can provoke a scramble for limited global resources and commodities and in turn generate conflicts never faced earlier. To counter potential conflicts, we need to remove the cultural stereotypes promoted by colonialists as a policy to "divide, conquer, and rule." Realistic mutual understanding by a dialog of civilizations rather than a clash of civilizations is a must for global peace with justice to prevail. Besides this moral imperative, it is also incumbent on the part of the academe to amend the historical records about the origins of Western higher education and scientific development.

For us in the West, it is also vital to cope with increased competition in global trade. The neo-colonialist desire of Darwinian domination needs to be civilized through fair competition and healthy cooperation. For sustained development our media also needs to cultivate in the audience a taste for truth and wisdom, for objective rational and responsible journalism instead of resorting to sex, violence, and sensationalism based on the "If it bleeds, it leads" type of programming. Pompous pride and complacency need to be replaced with an accurate understanding of our own strengths and weaknesses. A valid assessment of their past accomplishments and present predicament can enable Muslims to educate themselves and their future generations properly, and, in turn, enable them to plan realistically their further progress with great confidence.

Moreover, Muslims should also compensate for their own failure to tell the world their own story, which has been distorted by ignorance, arrogance, and often by malfeasance of anti-Islamic forces of material greed and bigotry. Without being defensive, Muslims ought to fill this knowledge gap in cross-cultural understanding.

CONTRIBUTIONS TO SCIENCE IN GENERAL

One of the attributes of science is that it is incremental and cumulative in nature. All scientifically and technologically developed nations have to pass through three phases: translation, coordination, and contribution.[1] They correspond to the three terms mentioned earlier: inheritance, improvement by innovation and creation, and transmission of knowledge. The intervals between these stages of development have varied according to the size of the existing knowledge base as well as the level of communication technology and speed of life as a whole. Thus, comparatively speaking, the narrower the inheritable knowledge base available to a generation, the more significant its contribution. The real value of the Muslim contribution to science ought to be assessed in view of the attitudinal change humanity experienced as a result of the advent of the Qur'an in the early sixth century AC.

James Burke, III, in his book *The Day the Universe Changed*,[2] asserts that prior to the advent of the Qur'an, human attitude toward nature was either that of fear or adoration and devotion. Created things that generated in humans a feeling of fear, like snakes and other dangerous animals, were worshipped to avert potential harm from them. Also venerated were beneficial elements of nature like water and fire, as well as animals, such as the cow etc. This veneration stemmed from humankind's gratitude for and admiration of their benefits.

The Qur'an, on the other hand, commanded human beings not to worship nature or any other part of Divine creation, but to bow down to their Creator, God. It invited human reason to search for His signs in creation and to draw lessons for their own evaluation and development. It is this pioneering role of Muslims on the basis of which their contribution ought to be compared with others. It was this revolutionary change in human attitude toward nature and the emphasis on reason that empowered Muslims to study nature from a scientific perspective, and to change the Universe forever, as it were. Again, it was the need of Muslims to fulfill their Islamic obligations that soon led them to develop mathematical formulae to calculate the passages and phases of the moon, and the location of the sun and various stars. The Qur'anic commandments concerning Zakah (welfare tax) and the shares of inheritors in the property bequeathed by parents and other relatives led to the development of calculus, trigonometry, and other devices for meticulous calculations.

Ibn al-Haytham's scientific method, erroneously attributed to Francis Bacon, led to phenomenal breakthroughs in different descriptions of natural sciences, which eventually led Europe toward its scholastic tradition and subsequently to the Renaissance.

By dint of the Qur'anic emphasis on the use of reason in all deliberations, Muslim scientists utilized a logico-empirical methodology of research and showed that there was no incompatibility between reason and Revelation. So unlike the Western tradition, from the Muslim scientists' perspective there has not been any conflict between science and religion. Alvi & Douglass[3] have identified five major reasons for the seminal development of Islamic science: (1) the immense esteem that Islam accords to scholarship; (2) the generous support by rulers and other affluent people that is available to scholars; (3) the willingness of Muslims to exchange ideas with others); (4) the Arabic language soon becoming a means of exchange of ideas throughout the Muslim world; and (5) the requirements of precision and punctuality in fulfilling Islamic duties. These notions are also affirmed by Colish.[4]

Historically, the knowledge of logic and geometry traveled from their Phoenician roots, originally from Iraq, to Egypt, and from Egypt to Greece. Muslim scholars then inherited them from the Greeks. They took astronomy and arithmetic from their Indo-Iranian origins and advanced them further to unprecedented levels.[5] Thus the entry of Muslims into the domain of organized knowledge helped humans to journey from "sapience" to "science".[6] On the subject of Islamic astronomy, Owen Gingerich[7] says that while astronomy withered in medieval Europe, it flourished in Islam. Renaissance astronomers learned from the texts of Islamic scholars who had preserved and transformed the science of the ancient Greeks.

As has been pointed out earlier, Ibn al-Haytham's logico-empirical method enabled subsequent scientists to make phenomenal advances in numerous scientific disciplines, both basic and applied. Muslim scientists realized that the proper place for empiricism was only in the domain of physical phenomena, not in the metaphysical ones. However, once the latter were revealed, they made logical and rational sense evidenced by analysis of historical events. They, therefore, classified knowledge into two broad categories: revealed and acquired.

DEMOCRATIZATION OF KNOWLEDGE

The true significance of Islamic sciences can be understood only in the light of the Qur'anic concept of *Tawḥīd* (Unity), which encompasses all apparent diversity and interdependence. The interconnectedness of everything in the universe indicates the unity of cosmos. It logically follows that the creator or programmer of this supra-system must be One, otherwise there would be chaos instead of cosmos. The third unity is that of all forms of life. God clearly stated in the Qur'an: "We have created every living thing from water" (21:30, 24:45, 25:54). This revelation was made at a time when this "unity of life" was not part of human knowledge, indicating the divine origin of the Holy Qur'an. From the point of view of human relations, it is vital to appreciate the value of the fourth unity, namely, that of the human race, created from one single soul a pair, and from them the whole of humanity (2: 213, 4:1, 39:6, 31:28). This concept of "monogenesis" enabled Muslims to democratize all knowledge. A Sudanese scholar, Dr. A. Waheed Yousif,[8] who is currently an advisor to UNESCO, showed with documentary evidence that the twentieth-century 20-point lifelong education mission attributed to the United Nations, existed in practice during the early Muslim Abbasid period of the ninth century. There, for the first time in human history, access to all knowledge was made available to all, regardless of gender, race, ethnic origin, caste, class, nationality, or any other factor on which human beings have no control. Contrast this Islamic democratization of science and other forms of knowledge with the strict restrictions imposed by the privileged upon the downtrodden communities of all other cultures, including Greek, Roman, Persian, as well as Indian until recently.

During the seven hundred years of their leadership in science and technology (from the eighth to the fifteenth century), Muslims introduced these disciplines into higher education institutions, which they established throughout the regions ruled by them. Their universities in the Near East, North Africa, and Spain provided an open-access model for the Spanish Muslim universities at Toledo, Córdoba, and Seville attracting students also from other parts of Europe. They saw for themselves this democratization of learning and participative decision-making ("*Shūrā*") in the Muslim world. Once back in their own lands, they started to demand similar human rights from their Church and state. When they were denied these rights, they "protested" against the authorities, the Church and their feudal lords. This was precisely the origin of the Protestant movement in Europe.

The fifth unity in Islam is the unity of knowledge (truth). Unaware of the Qur'anic origin of this concept, the Harvard University Biologist, Edward Wilson,[9] presented the notion of "consilience" in his book of the same name, and stressed the need for interdisciplinary studies to overcome the myopic and disjointed pursuit of knowledge called "reductionism." From an Islamic perspective, this unity of knowledge and truth is nothing new.

The Muslim introduction of higher education, meticulous documentation, chapter making, Arabic numerals as well as other advanced applications of scientific knowledge to agriculture, medicine, architecture, and navigation led to the gradual advancement of Europe, eventually culminating into the Renaissance and Reform movements of the fifteenth and sixteenth centuries. The subsequent European colonization of the Americas resulted in the transfer of gold and other forms of wealth to Europe. During Muslim rule itself, centers of higher learning, research, and development, institutes, libraries, teaching hospitals, science laboratories and observatories became common in Muslim cities like Madinah, Damascus, Baghdad, Neshapore, Cairo, Qairawan, Córdoba, Toledo, and Seville.[10] This spree of institution building and development was emulated in Italy, France, Germany, England, and other parts of Europe.

Without Arabic numerals, advanced mathematical calculations could not be imagined given the limitation of Roman numerals. One can get a general idea of the scholarly activities of the Muslim world from Ibn al-Nadīm's *al-Fehrist* (tenth century),[11] which lists about four thousand prominent scientists and other scholars. Ibn Khallikan's biographical dictionary titled *Wafiyat al-ʿAʿyān wa Anbā' Abnā' al-Zamān* in seven volumes documents similar protagonists and their contributions in various fields of higher learning.[12] Many other reference resources have documented the Islamic cultural milieus and their history of various disciplines and subdisciplines. Although numerous works of the Muslim scholars of that period have been translated from Arabic into modern European languages, it is estimated that about seventy thousand of them still remain untranslated.

CONTRIBUTIONS TO MATHEMATICS

As has been pointed out the Qur'anic commandments concerning the five daily prayers, the beginning and end of the fasting month of Ramadan, the distribution of inheritance, and the calculations of Zakah (welfare tax) called upon Muslims to be proficient in mathematics. Since an advanced language can be a means of communication in the humanities and social sciences, mathematics is considered to be the language of the natural and physical sciences. From the eighth century AC, Arabic became a language of higher learning, and mathematics written in Arabic numerals and symbols was the language of science for about seven centuries.

The Muslims introduced the Arabic numerals (originally borrowed from India), the concept of the zero, the decimal base of ten, and advanced mathematics into Europe. Prior to the eighth century, one had to write the letter "M" a thousand times to indicate one million. Imagine the ease of writing the same thing in only seven digits. By the ninth century, al-Khawārizmī had already given the world advanced algorithms or formulae. Notice that the English word algorithm is simply the Europeanized form of this Muslim name, al-Khawārizmī, who gave the world the first mathematical formula and trigonometry (sine, cosine, tangent, and co-tangent). The arithmetical and geometrical concepts and calculations of pi, hyperbole, series, and progressions, are also Muslim contributions to advanced mathematics that were later introduced into Europe.

It was the Muslim scholar, al-Mutawakkil al-Farghānī, who invented

Nilometer devices. More sophisticated devices like compasses were originally designed for determining the direction of the Kaʿbah, the cube-like Mosque of Prophet Abraham in Makkah, toward which all Muslims face while praying. Speaking of the inherent relationships between Islamic beliefs and values, Jane Norman states:

> Appreciation for a basic relationship between art and the religion of Islam increases with familiarity ... Geometric motifs were popular with Islamic artists and designers in all parts of the world, at all times, and for decorating every surface ... As Islam spread from nation to nation and region to region, Islamic artists combined their penchant for geometry with pre-existing traditions, creating a new and distinctive Islamic art. This art expressed the logic and order inherent in the Islamic vision of the universe.[13]

CONTRIBUTIONS TO CHEMISTRY

Their victory in Western China in the eighth century enabled the Muslims to benefit from contemporary Chinese technologies, such as paper-making, which they in turn introduced into the entire Muslim world including Spain. From there it was taken to the rest of Europe. This indeed was a revolutionary discovery leading to the wider dissemination of knowledge and democratization of learning. With the expansion in the exchange of ideas in the form of conveniently transportable books, and owing to the monogenetic concept of the equality of humankind, the earliest explosion of knowledge became possible throughout the world.

Muslims made tremendous progress in the field of chemistry, of which the Arabic *al-kīmiyah* is the etymological origin. They invented all the fundamental processes of chemical research and development, including sublimation, crystallization, evaporation, distillation, purification, amalgamation, and acidation (sulphuric, nitric, hydrochloric, and acetic). They then applied these processes to the manufacture of sugar, various types of dyes, alcohol, and arsenic for mostly medicinal purposes. By 950 AC, they had discovered how to heat mercury (Hg) to form mercuric oxide (HgO), noting that this chemical alteration does not cause any loss of weight of the basic substance itself. Muslims, owing to the Islamic emphasis on cleanliness and aesthetics, were fascinated by the chemical purification of gold to be used in making jewelry and preparing food, as well as in architectural decorations.

CONTRIBUTIONS TO PHYSICS AND ASTRONOMY

By the ninth century, Muslim scientists had discovered the laws of the strength of materials, mechanics, and stability. In his study of the laws of physics, al-Kindī scientifically described the phenomena of reflection and refraction of light, theories of sound and vacuum. The tenth and eleventh centuries saw the Muslim scientific principles related to the pendulum long before Galileo (1564–1642). Not until 1992 did the Pope forgive Galileo for the heresy of teaching that the Earth revolved around the Sun. In the 10th century, Ibn al-Haytham described and utilized his scientific method. It is worth noting that the term "science" was never used in Europe until 1340 AC, and it was only in 1840 AC that the word "scientist" was used in the English language for the first time. Ibn al-Haytham's findings on geometrical optics in 965 AC, which were later utilized in European inventions like cameras and sophisticated eyeglasses, are erroneously attributed to Snell (eighteenth and nineteenth centuries) as Snell's laws.

Muslim scientists also discovered the principles of homogeneity and heterogeneity in the context of rarefied air. Concepts and kinds of aberrations of images were explored and utilized in manufacturing lenses and mirrors. Not only did they know that light has velocity but they also compared velocities of light and sound and found that the former was greater than the latter. They studied and formulated laws of mechanics and hydrostatics, which they used in determining tensions of various types of surfaces, specific gravity and density of different forms of matter.

The concept of earth's gravity was known to Abū al-Fatḥ ʿAbd al-Raḥmān al-Khāzinī in the twelfth century, that is, several centuries before Isaac Newton, who only further refined it. It was al-Khāzinī himself who also explained the natural phenomenon of the rainbow in optical terms. He is credited with designing many astronomical instruments described in his *Mīzān al-Ḥikmah*.[14]

ʿUmar al-Khayyām of the twelfth century, who is known to the Western world only as a poet of the Persian *rubāʿiyyāt* (quatrains), made remarkable contributions to mathematics as well. He refined calendar calculations, by pointing to the existence of a one-day error in 5,000 years instead of the 3,330 years presumed earlier. Another Muslim, Ulugh Beg of Samarqand, further refined his calculations. Al-Khawārizmī, who has been mentioned above for his contributions to mathematics, was also the founding father of Islamic astronomy. Several centuries before Galileo, he and his followers had known the earth to be spherical, and he himself had calculated distances between various cosmic bodies.

The ninth-century scientist and astronomer, Abū Maʿashar, had accurately drawn latitudes and longitudes, discovered the relationship between the phases of the Moon and the ocean tides, scientifically explained lunar and solar eclipses, and refined calculations of the differential in the earth's circumference at different points of the globe. It was he who very accurately measured and explained the length of the terrestrial degree to be 56.67 Arabic miles.

Al-Saʿati Khurasānī, who is named after his invention of the clock (*sāʿah*: also time), of the twelfth century built a clock tower in Damascus, Syria. It was the Muslim geographer, al-Idrīsī, who presented King Roger II with the gift of his silver globe. Abdur Rahim identified and named about a thousand stars, and explained the elliptical paths of cosmic bodies in the known solar system. He is also credited with his significant researches in other fields like agriculture, architecture, literature, and linguistics.

In the field of applied physics, al-Jazzarī in the thirteenth century proved his prominence in his book dealing with the subject of hydraulic appliances, *Kitāb al-Maʿrifah wa al-Hiyal al-Handasah*. His contemporary, Najm al-Rammah, gained fame in his exhaustive volume on pyrotechnic techniques and devices, for both defense and ceremonial uses.

In 845 AC, that is hundreds of years before Darwin, al-Naẓẓām presented the theory of evolution. Within the same time frame, al-Jāḥiẓ wrote a voluminous treatise on animals, their struggle for survival and adaptation to physical environments. As early as the ninth century, al-Ḥāsib wrote a volume on the benefits of precious stones. Later, in the thirteenth century, his co-professional, al-Tifāshī, improved his work and added his studies on 24 precious stones and their affective and medicinal properties. Many others like al-Jawāliqī, ʿAbd al-Mumin, and al-Dhāmirī, made immense contributions to knowledge with their treatises on zoology and anatomy, especially on horses and their breeding.

Al-Dimashqī made his mark in botanical studies on plant pathologies, categorizing plants as living beings with a distinctive gender. Al-Bayrūnī, generally renowned as a historian, discovered the origin or source of the Indus Valley and its civilization. He also observed that the number of petals in flowers vary between 3 and 6, or they are 8. They never number 7 or 9. These and many other Muslim scientists left a rich scholarly legacy in Africa, Asia, and Europe.

DECLINE OF MUSLIM SCIENCES

The question is often raised of why Muslims at some point in history stopped developing in the fields of science and technology. There were many factors, both internal and external, affecting their stagnation and decline. Historically, in the case of most dominant powers, arrogance, ignorance of other societies and their state of development, and topsy-turvy priorities have been the major causes of internal weaknesses. Successes and their sustenance call for a balanced approach to different demands of human life, of body, mind, and soul. When this moderation is disturbed anomie sets in.

In its heyday, Islam was practiced as a comprehensive way of life. An overemphasis on its spiritual aspect continued to reduce its original scope. Consequently, many crucial concepts associated with it also diminished. The concept *ʿIbādah* (worship), which originally meant any practical act pleasing to God, became mere ritualistic prayers. The *nawāfil* any extra deeds of charity, turned into only excessive ritual prayers; and the concept of seeking knowledge became confined to mere theological learning. The roles of reason and creativity were played down even in areas where they were originally permissible, such as in the economic, political, and social domains.

The Muslims perhaps ignored the illustrative dialog between the Prophet and his Companion, Maʿādh ibn Jabal, when the latter was being dispatched to the governorship of Yemen. On this occasion, Maʿādh, in response to the Prophet's question of how he would rule there, had said that in cases where there was no clear-cut answer in the Qur'an and the Sunnah (Prophet's Sayings), he would do ijtihad. That is, he would form his own rational judgment from a pragmatist and problem-solving perspective. The answer had obviously satisfied and pleased the Prophet.

Moreover, there had been an internal debate and later a showdown between the Muʿtazilites, who were influenced by the Hellenistic starkly rationalistic analysis, and the Ashaʿarites, who had the theological approach to even new issues facing the the Ummah (the global Muslim community). The latter were traditionalists who relied on the analogical interpretations to the extent that they assumed that early scholars of Islam had finally interpreted the Qur'an and Sunnah for all times and climes. This myopic mindset of the traditionalists was not without reason. They had seen the excesses of Hellenistic hypocrisy in ignoring the limits of human reason in the form of fallacious acceptance of over-relativism, which is bedeviling contemporary thinking in almost all walks of life. While some rulers took advantage of the misuse of creativity and innovation in the name of ijtihad, others sided with the traditionalists in suppressing even the genuine use of all rational tools of development.

The sad result of this conflict between *riwāyah* (tradition) and *dirāyah* (rationalism) was the stagnancy and closure of the doors of rational and analytical genius of Muslim scholars and scientists. The religious scholarship became restricted to memorization of quotations and copying of old manuscripts from past scholars. The lone major voices since the eighteenth century urging the revival of ijtihad included Ibn Wahhāb, Shāh Waliullāh, Sir Syed Ahmed Khan, Jamaluddin Afghani, and Mohammed Abdu, as well as Mohammed Iqbal and Mawdudi. All of them stressed the need for a balance between the blind adherence to traditions on the one hand and, on the other, bold yet cautious interpretation of the same traditions within the framework of the seminal sources of Islam, and in light of the context and demands of specific times and places. They urged the Ummah to distinguish between *ijtihad-e-muṭlaq* (absolute exertion) through scholarly consensus and *ijtihad-e-idhāfī* (relative exertion) by renewing the old principles of Shariʿah to handle new situations facing the community.

With regard to external challenges, the Muslim community has faced historical events such as the eleventh-century Crusades, the siege of Baghdad by the Mongols in 1258, expulsion from Spain in 1492, the end of the Caliphate in 1922, communism and colonialism, and more recently neocolonialism resulting from oil politics accompanied by a powerful media onslaught, stereotyping victims as oppressors and oppressors as victims.

Other significant Muslim contributions are summarized below in Appendix 1 to this chapter. In view of Basheer Ahmed's chapter, in this book, on Muslim contributions to medicine as well as the chapters by other participants on social sciences and humanities, I have limited myself to works on the modern natural sciences only.[15]

APPENDIX ONE

Contributors to the Origins of World Science

PERIOD	SCIENTIST	REMARKS
721–815	Jābbir ibn Ḥayyān (Geber?) Founder of modern chemistry Logician Philosopher	3000 treatises on (Wālid ib Mālik) Scientific method concept and measurement of chemical balances Physics: mechanics Medicine: clinical pathology Contributed to the establishment of the first medical college at Damascus
Abbasid		*Bayt al-Ḥikmah* at Baghdad, Iraq
801–873	Abū Yūsuf al-Kindī (Al-Kindus) The Philosopher-Scientist of the Arabs	Precursor to al-Fārābī Description of the inhabited parts of the Earth Al-Shammāsiyyah Observatory, Baghdad Global postal service Book of Countries Contemporary of Hishām al-Kalbī and al-Yaʿqūbī
810–877	Ḥunayn ibn Isḥāq (Juannitius)	Physician-Philosopher Commentator on Galen

PERIOD	SCIENTIST	REMARKS
826–901	Thābit ibn Qurrah	3000 Volume of paraboloid 3rd degree figures in Geometry Mathematics Physics, Medicine, Astronomy Theory of Repidation Naval developments (Indian Ocean; Volga & Caspian Sea) Early maps Contemporaries: Balakhī, Maqdisī
?–863 (period of al-Maʿmūn)	M. al-Khawārizmi (algorith)	*Al-Jabr wa al-Muqābalah* (advanced algebra) Introduction of Arabic numerals into Europe Trinomial equations Astronomical tables Innovative computations Geography: shape of the Earth Observatory at al-Shammāsiyyah (with Naubakht)
865–925	Muḥammad al-Rāzī (Rhazes) (184 workers) Clinical Physician (Al-Ḥāwī): Continens anti-Aristotelian speculations	Smallpox/measles Observatory at Raqqa (Shiraz) Contemporaries: Abū al-Wafā al-Buzjānī (4th degree equations), al-Karakhī

PERIOD	SCIENTIST	REMARKS
	Emphasis on time, space & causality in physics: direct observation of hard data	
	Music to alchemy Student of al-Ṭabarī	
870–950	Abū Naṣr al-Fārābī (Alpharabius)	Commentaries on works of Aristotle
	Philosopher	First classification of sciences
	Social Scientist	*Ikhwān al-Ṣafā* *Risālat al-Jamia*
?–956	Abūl Ḥasan al-Masʿūdī	Travelogues Meadows of Gold & Mines of Gems
	Scientist Historian Anthropologist Geographer Geologist	
980–1037	AbūʿAlī ibn Sīna (Avicenna)	Shaykh al-Rais
	Medical scientist Physician	Cannon (*al-Qānūn*)
		Kitāb al-Shifā'
		Dār al-ʿIlm (Cairo) Observatory at Hamadan
		Scholarly conferences & proceedings
965–1039	Abū ʿAlī al-Haytham (Alhazen)	*Kitāb al-Mākir* (Optics) first eyeglasses (lathe)
	Mathematician Physicist (astro)	Scientific method
	Medical scientist Ophthalmologist	Measurement of the Nile floods

PERIOD	SCIENTIST	REMARKS
		Observatory at Seville (Falah) Spherical and parabolic mirrors; refraction angles and velocity Principle of least time Contemporaries: Nusairī Khusro (Diary); al-Bakrī (Dictionary of Geography)
937–1051	Abū Rayḥān al-Bayrūnī Contributions to Mathematics; Astrophysics; Geography/Geodesy History and anthropology	Commentaries on Aristotle Chronology of ancient nations Canon of al-Masʿūdī Astrolabes (used in navigation) Motions of the earth Levity and gravity of planets Elliptical orbits Contemporaries: al-Khāzinī (Physics): inclination impetus, momentum
? –1007	Abū al-Qāsim al-Majritī (Madrid, Córdoba) Mathematics, Chemistry, and Astronomy	Epistles of al-Ikhwān Observatory at Toledo (Zarqali)
1058–1111	Abū Ḥāmid M. al-Ghazālī (Algazel) Philosopher Religious scientist	The revival of religious sciences Contemporaries: Manṣurī/Nurī (Hospitals) Al-Idrīsī (Geography: the globe, and botany)

PERIOD	SCIENTIST	REMARKS
12th c.	Raḥmān al-Khāzinī	Scientia vs. sapientia
	(The Greek)	Mechanics and hydrostatics
		Centers of gravity & balance of matter & balance of wisdom
		Standards: weights
1040–1130	Abū al-Fatḥ ʿUmar Khayyamī (Omar Khayyam)	Algebra
		Quatrains (translated into English by Fitzgerald)
	Mathematician Scientist Poet	
1126–1198	Abū al-Wāḥid M. ibn Rushd (Averroes of Córdoba)	Pure Aristotelian (38 commentaries)
	Medicine Religious Law Comparative Studies	
1201–1274	Naṣir al-Dīn al-Ṭūsī	Universal Scientific genius
	Mathematics Astronomy Philosophy	The Ṭūsī Couple
		Saved libraries from Halagu (Observatory at Maragha)
		New planetary models
1236–1311	Quṭb al-Dīn al-Shīrāzī	Commentaries on Canon of Ibn Sīna
	Medicine (optics) Mathematics (Geometry) Astronomy/Geography Philosophy	Encyclopedic works on Astrophysics

PERIOD	SCIENTIST	REMARKS
1332–-1406	Abd al-Raḥmān ibn Khaldūn	*Kitāb al-Ibar*
	Philosophy and science of history (Historiography) Psychology Father of social sciences	History of North Africa *Al-Muqaddimah* Rise and fall of cultures Contemporaries Kashānī *Qazizadah* (trigonometry: value of pi) Observatory at Samarqand Busti, Maridini
1546–1621	Bahā'uddīn al-ʿAmilī	Shaykh al-Islam Applications of Mathematics & Geometry to architecture
	Mathematics, Chemistry Architecture Religious Sciences	 Decimal fractions Contemporaries: Yazdī & Isfahānī