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Science and Epistemology in Medieval Islam[1]

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"Islamic" science or "Arab" science? [2] This is a relevant question. Arabic language, the vehicle of the Islamic revelation, was as well the vehicle of great scientific knowledge although not every "Arabic" scientist was Muslim, nor was every Muslim scientist an Arab. In the very first years after the expansion of Islam, numerous Christian and Jewish investigators, and even "pagan" ones (such as the famous astronomer-philosopher Thabit Ibn Qurra from Harran, Mesopotamia, d. 901, who worshipped the stars) communicated in Arabic. The Bakhtishu', a family of physicians from the Persian school of Gondeshapur, who served the Omayyad and 'Abbasid Caliphs, where Nestorians. The great translators of Greek or Syriac works into Arabic were Nestorian or Jacobite such as Hunayn Ibn Ishaq (Latinized in Ioannitius), who worked at the House of Wisdom or *Bayt al-Hikmah*, founded in Baghdad by Caliph al-Ma'mun (813-833). Mashallah, the greatest astronomer of the courts of al-Mansur and Harun ar-Rashid (786-809), was Jewish.

Islamic Science

We should speak of "Islamic" science, not only because it was transmitted in Arabic (and also in in Persian) but, first and foremost, because despite the Greek, Syrian, Christian and Indian influence, it was animated and characterized by Islamic religious spirit. We thus need to take into account strictly religious elements, but also historico-political ones since it was through Islam that Arabs, Persians, Indian, Malaysians, Turks and Chinese enjoyed a spiritual brotherhood.

In the first place Islamic civilization, although it was born in a desert and spread by essentially nomadic people, soon began a strong process of urbanization and developed an organization of work in which artisans and merchants prevailed over peasants. It is true that the Prophet had been a merchant before receiving the revelation and that Mecca was an important hub for caravans on their way from Yemen to Syria. Yet the Islamization of the Persian Empire and of Coptic Egypt, as well as of the conquest of vast territories of the Byzantine Empire and of India deeply transformed those nomads. The Islamic expansion entailed a remarkable increase in economic transactions, as well as the consolidation of caravan and maritime routes that spanned from China to the Herculean Columns, and a wider circulation of money.

It is relevant, even before examining the epistemological foundations of Islamic science inscribed in the Qur'an, to remember that one of the most cultivated Islamic sciences was

[1] Adapted and translated by S. Bigliardi under Massimo Campanini's supervision from "Scienza ed Epistemologia nell'Islam medievale," *Nuova Civiltà delle Macchine*, 2 (42), April-June 1993, pp. 16-27. Editing by Liesl Drew. The transliteration of Arabic and Persian terms and names is rather simplified without diacritical marks and *ta marbuta*.

[2] For some "classic" monographs about Islamic-Arabic science see: A. Mieli, *La science arabe et son rôle dans l'évolution scientifique mondiale* (Brill, Leiden, 1966, 2nd ed.); DeLacy O'Leary, *How Greek Science Passed to the Arabs* (Routledge and Kegan Paul, London, 1951): R. Walzer, *Greek to Arabic* (B. Cassirer, Oxford 1962); A. al-Hasan and D. R. Hill, *Sciences et Techniques en Islam* (UNESCO, Paris, 1991). S.H. Nasr, *Islamic Science. An Illustrated Study* (Insan Yayinlari, Istanbul, 1986). D. Gutas, *Greek Thought, Arabic Culture* (Routledge, London and New York, 1988). Nowadays obviously there is a huge literature.

geography, and that the Muslims were deeply interested in anthropological and historical studies. We can mention here at least the Moroccan Ibn Battuta (d. 1368/1369), Ibn Hawqal (10th century), author of the *Book of Roads and Kingdoms* (*Kitab al-Masalik wa'l-Mamalik*), and Yaqut al-Hamawi (13th century), author of a *Geographic Dictionary* (*Mu'jam al-Buldan*). These books are characterized by a special taste for observation and concreteness, but Yaqut for instance states that he practices geography since knowing and describing God's work is a religious duty. It is true that the interests of some geographers or anthropologists might seem limited to the Muslim world. We should nevertheless consider the gap between Islam and the "West" that remained wide at least until the 14th century; but even the sense of pride in Islam considered as the best religion and the resulting "closure"[3] should not be overstated because at its apex Muslim civilization was rather open and tolerant.

Technique and technology were cultivated and perfected by the Muslims as well, who should not only be mentioned as the "transmitters" of the "Arabic" numerals from India, or of the compass from China to the West. They strove to improve the manufacture and usage of essential tools for merchants and travellers: sky maps, armillary spheres, and, most importantly, astrolabes.[4] Technique and gnosis went hand in hand when maps of the constellations and astrolabes were used not only as tools for sailors but also as instruments to decipher the astrological code of the sky.

Typical of the Muslim mind set, including the scientists', is a certain amount of syncretism concerning both methods and subjects. Given the will of religiously understanding any aspect of reality in the religious framework no epistemology or piece of information was rejected *a priori*. An example of such "Islamic genius" is the polymath Abu Rayhan al-Biruni (d. 1051) who lived at the court of the Ghaznavids in Afghanistan. He contributed to a number of fields including astronomy (although he did embrace Ptolemaic geocentrism, he discussed the heliocentric hypothesis with great balance), mineralogy, geography (most notably with his description of India, *Kitab al-Hind*, in which he dispassionately discussed Hinduism), and astrology.

Evaluating Islamic Science

Islamic science must be understood and evaluated, historically and epistemologically, by referring to the Qur'an. We will never emphasize enough how the whole Islamic civilization revolves around a pivotal concept: *tawhid*, i.e. God's unity and unicity. However this has been interpreted in deeply divergent ways. For instance, Seyyed Hossein Nasr considers it an epistemological principle—all Islamic sciences and arts were, in his opinion, striving towards the demonstration of the unity and consistence of all natural reality that in its turn mirrors the unity and unicity of God.[5] However, Alessandro Bausani suggests that the Islamic God is first and foremost a *legislating*

3 This is what Montgomery Watt calls "self-sufficiency" and criticises (not always convincingly) in *Islamic Fundamentalism and Modernity* (Routledge, London and New York, 1988). Another supporter of this view, mainly in politics and broadly in civilization, is Bernard Lewis.
4 See for instance L. A. Mayer, *Islamic Astrolabists and their Work* (Geneva 1956); D. King, *Islamic Astronomical Instruments* (Variorum Reprints, London, 1987).
5 See for instance S. H. Nasr, *Islamic Cosmological Doctrines* (Thames and Hudson, London, 1978).

individual and that *tawhid,* far from being a methodological principle, is rather a juridical or political statement aimed at emphasizing Islam's identity (i.e. distinguishing it from paganism and polytheism including the doctrine of the divinity of Jesus and the Trinity).[6]

If we examine the Qur'an in the attempt at solving the controversy between Nasr and Bausani we are left in puzzlement. In fact, the Sacred Book contains juridical prescriptions (concerning penal and civil right), as well as the exaltation of God's infinite transcendence and gnostic verses open to infinite allegorical interpretations. Although I am personally inclined towards Bausani's interpretation, *what is decisive in my view is that the Qur'an does invite scientific knowledge to be used towards a rational understanding of the world*. One needs to observe the "signs" in the world in order to understand it.

According to a doctrine that was also adopted in the Western Middle Ages, the Book of God is an archetype of the universe while the cosmos is an open Qur'an. Furthermore, the Book contains hints of a creation narrative as well as the idea that the cosmos is perfect and its order is regulated by the motion of celestial bodies. Qur'anic passages, obviously, do not offer any concrete data to scientific thought (although the "scientific exegesis" — *tafsir 'ilmi*—of the Book claims that this is the case). However, Qur'anic passages do have epistemological relevance, especially if we consider the Islamic custom of corroborating scientific conclusions with quotations from the Sacred Book, allegorically interpreted (and sometimes even forcibly invoked). Finally, the hierarchical classification of science (in which the greatest Muslim gnostics are engaged including philosophers and scientists from al-Kindi to al-Farabi, Ibn Sina (Avicenna), al-Ghazali, Nasir ad-Din al-Tusi and Mulla Sadra) was functional to the demonstration of their convergence in the Divine wisdom (both meant as entirely present and systematically ordered within God's mind, but also as conducive to the knowledge of God).

If we refer to the Qur'an as a starting point we can identify three kinds of approach to scientific knowledge: experimental and observation-based; rational and speculative; gnostic and illuminationist. The three levels can overlap but there are disciplines and research fields in which one of them prevails over the others.

Medicine was, for instance, a prevailing experimental and observation-based discipline, so that authoritative thinkers such as al-Ghazali, Averroes, and Ibn Khaldun considered it an art rather than a science. However, Arab-Islamic medicine was extremely fertile and it enjoyed such a positive reputation that it was studied in Europe until the 17th century.[7] The two greatest Muslim physicians were Abu Bakr Muhammad Ibn Zakariyya al-Razi (Latinized into Rhazes, d. 925) and Abu 'Ali al-Husayn Ibn Sina (Latinized into Avicenna, d. 1037). The former wrote a treatise on smallpox and measles that was authoritative for centuries; the latter wrote the *Canon of Medicine* (*Al-Qanun fi'l-Tibb*).

6 See for instance A. Bausani, "Cosmologia e religione nell'Islâm," *Scientia*, LXVII, 1973, pp. 723-746.
7 See for instance F. Klein-Franke, *Vorlesungen über die Medizin im Islam* (Harassowitz, Wiesbaden, 1982); F. Rahman, *Health and Medicine in the Islamic Tradition* (Crossroads, New York 1987); D. Jacquart and F. Micheau, *La médecine arabe et l'Occident médieval* (Maisonneuve, Paris, 1990); F. Rosenthal, *Science and Medicine in Islam* (Variorum Reprints, Aldershot 1991). M. Ullmann, *Islamic Medicine* (Edinburgh University Press, Edinburgh, 2004).

We should also remark that they both based their clinical research on attentive evaluation of symptoms as well as on accurate anatomic knowledge. Both authors were first and foremost philosophers and their speculative inclination is surely mirrored in their modern epistemological approach as physicians. However, if we look at their philosophical ideas proper, they can hardly be defined as scientists.

Rhazes was, on the one hand, rationalist up to the point of questioning Muslim faith as well as the necessity of prophecy but, on the other hand, with his doctrine of the "five eternals" (God, matter, soul, space, time) and of metempsychosis he leaned towards Sabaean and Indian currents of Neoplatonism and Pythagoreanism so that he ended up systematically criticising Aristotle. Avicenna wasn't just an Aristotelian (although with strong Platonic leanings) but also possibly a Shiite and an *ishraqi*, that is, somewhat inclined to gnostic and illuminationistic positions (at least at the end of his life). Therefore, although the *Canon of Medicine* is a worthwhile handbook in matters of diagnosis, pharmacology and pharmacopoeia, one cannot help feeling that it is rather marginal if considered in the context of the author's overall production.

The frequent combination of philosophical inclinations and clinical practice that characterized many scholars should not induce us to disregard their fieldwork. Hospitals as institutions (*maristan* or *mustashfà*) appeared very early in the Muslim world. Rhazes for instance directed the hospitals in Rayy (his home town, next to modern-day Tehran) and in Baghdad. However it was primarily in Cairo that the sultans (such as the Mamluk Qalawun who reigned from 1280 to 1290) promoted the foundation of hospitals provided with libraries and centers of research.

Astronomy and physics were primarily speculative although there was an experimental side to them. The idea according to which the Arabs left astronomy at the same level they had found it [8] is misleading. It was a field in which their contributions were remarkable, both as to the systematization and organization of knowledge and as to research and direct observation. In his *Metaphysics* (*Kitab ma ba'd al-Tabi'a*) Averroes distinguished, within astronomy, the "mathematical art of the stars" from the "experimental art of the stars." Ibn Khaldun, the great philosopher of politics (d. 1406, Cairo), considered it a noble art and an important science, one of the pillars of mathematical disciplines but also as purely hypothetical.

The Pillar of Mathematics

The Muslims soon learned that mathematics is an essential support of science, so that astronomy and physics must be practised in a mathematical framework. However the connection between observation and calculation, rather than epistemologically explored and reflected upon, seems to have emerged rather spontaneously. The sources of Islamic astronomy are first and foremost Indian and Greek. Especially known and analysed was the work of Ptolemy, whose *Almagest* was substantially corrected by figures such as the above-mentioned Thabit Ibn Qurra, Jabir Ibn Aflah (d. 1150), and Muhammad Ibn Jabir

8 Expressed for instance by T. Dreyer, *A History of Astronomy from Thales to Kepler*, 2nd edition, Dover Publications, 1953.

al-Battani (d. 929), perhaps the greatest Muslim astronomer of antiquity. Another famous scientist was Abu ‘Ali al-Hasan Ibn al-Haytham (Latinized in Alhazen, d. 1039) who described planetary motions according to a model that was to be influential up until the time of Kepler. However he mostly dedicated himself to optics, elaborating a complex theory of vision in which he strove to combine his physical ideas, formulated in strictly mathematical language with ophthalmology.

Quantitatively, the greatest Islamic contribution to the study of planets and stars was in the field of applied astronomy, with the compilation of sky maps and the research conducted at the observatories. In this respect one must remark that the Sultans’ patronage was instrumental. For instance Ibn Yunus (d. 1009), among the first scientists who studied the pendulum motion, was generously supported by the Fatimid (Shiite-Ismaelite) Caliph of Cairo al-Hakim, to whom he dedicated his astronomical tables (*al-Zij al-Kabir al-Hakimi*). Observatories were founded in Baghdad and Damascus since the beginning of the 9th century under the patronage of the above-mentioned ‘Abbasid Caliph al-Ma’mun.

Astronomic calculations, as well as the determination of the motion and the position of planets and stars, was conducive to the admiration of the Creator’s perfect construction but also to the establishment of caravan and maritime routes, not to mention the correct identification of Mecca’s position, essential for the practice of prayer.

It should also be mentioned that even astrology (often overlapping with astronomy) was particularly scientific, more than the Greek one, given the predominant role that mathematics played in it. Islamic astrology influenced its “Western” counterpart up to an extent comparable only to that of medicine. One can mention, for instance, Abu Mash‘ar (d. 886) who elaborated a doctrine of “grand conjunctions” that determine the birth and fall of kingdoms as well as peoples. Astral influence was taken into account in medical matters as well, so that famous physicians were also astrologers, referring to the planets in order to understand physiology and choosing therapies. However, we must remember that astrology was fiercely opposed by Muslim theologians and philosophers on the basis of the idea that no astral conjunction can limit or determine God’s will. Even Averroes accepted the notion that the planets could exert some influence on the sublunary world, but he refused that astrologers could consistently refer to them in order to foretell future and destiny, rejecting at the same time their lack of systematization, their arbitrariness, and the utilitarian character of their activities.

Finally, alchemy was the gnostic and esoteric subject that, according to Muslim interpretations, dated back to Plato (and was therefore endowed with some “exotic authority”). Alchemists were basically gnostic philosophers who understood the relationship between the “inferior” and “superior” world, grasping the hidden (and hence occult) properties that things and substances do not immediately reveal. Furthermore, like a demiurge, they transformed matter. Such was the shadowy figure of Jabir (Geber) Ibn Hayyan (who allegedly lived in the 8th century), partly mythical or mythologized, a Shiite and most probably an Ismailite whose alchemical system, according to the “theory of the balance,” a precise order holds in proportion to substances astral and spiritual relationships. In his interpretation alchemical operations are a form of spiritual exegesis

aimed at "hiding the apparent and revealing the occult" while the elixir (*al-iksir*), the agent that operates the transformation, is equalled with the Shiite Imam whose coming marks the transformation of the world.

Perhaps the most intriguing question for all historians of science and philosophy alike is: *Why didn't Islam have a Galilei*? In other words: Why didn't such a vibrant, complex, varied, and advanced scientific activity not give birth to a "revolution" comparable to the one that took place in 16th century Europe?

An Absent Revolutionary

Upon first inspection one cannot fail to notice that favourable elements and factors were in fact present. We have already remarked how some sectors of Islamic science were observational and experimental. However, even more important was the role of mathematics. Among numerous Muslim mathematicians the most famous is certainly Muhammad Ibn Musa al-Khwarizmi (d. 863) who introduced Indian numerals and was among the first to consider zero as a number. The very terms "algorithm" and "algebra" respectively come from his name and from the title of one of his works. Omar Khayyam (d. 1130) developed an original method to solve cubic equations. Al-Kashani (d. 1429) calculated with utmost accuracy the value of pi. In the domain of physics the theory of *mail* or "inclination" developed by Avicenna can be compared to Newton's concept of *vis inertiae* and it contributed to the development of the theory of *impetus* by Buridan.

It is also true that *there was no Galilei in Islam also in the sense that there was no case of religious persecution against scientific research*. The researchers could make a strong case for their activities by referring to the Sacred Book and the Sultans were remarkably tolerant when not financially supportive. There is no clergy in Islam, particularly in the Sunni one, and there is therefore no "Church" in charge of interpreting the Scriptures with unappealable authority over them. If scientific conclusions did not impinge on the doctrines of the unity and unicity of God or of prophecy (and one does not see how medicine or mathematics could possibly do so) there was no reason to impede or oppose them. To be sure there were "persecutions" against philosophical doctrines (al-Ghazali reproached the philosophers for denying the creation of the world, the resurrection of the bodies, and divine omniscience) or against some extreme forms of Sufi mysticism, but not against "scientists."

My ambition is not to provide a definitive answer to the question as to why Islam did not have a Galilei, but rather to offer some more elements to reflect on. In my view, what Islam lacked was not a general openness or inclination to scientific research, but rather a consistent and self-aware reflection upon its epistemological foundation, that is, a "discourse on the method." I do not completely agree with the view according to which the '*ulema'* (jurists) determined, with their hostility towards philosophy, a decline in science as well;[9] however it seems likely that the prevalence of the juridical-legal thought did not encourage the reflections upon the methodology of science either. Paradoxically, it was the emphasis on the religious and social element of knowledge, aimed at ordering

9 W. M. Watt, *Muslim-Christian Encounters* (Routledge, London and New York, 1991).

life on earth as well as at guiding humans to their otherworldly destiny that veiled the goal and the autonomous value of science and technology. Montgomery Watt pointed out that while in the West knowledge is for power (Francis Bacon), in the East (and consequently in Islam) knowledge is for living and is not aimed at the "domination" of nature.

We should also take into account that within Shiism, although more inclined to philosophy and speculation than Sunni Islam, esotericism took the upper hand. Shiite thinkers ended up identifying revelatory signs and prophecies in history and regarding nature as theophany or a manifestation of God. Although this bestowed on Islam spiritual depth, it also conferred a specific transcendent character that did not favour the birth of a *philosophia naturalis* like Galilei's or Descartes' one.

In order to correctly evaluate the Muslim attitude towards science I would like to touch upon three case studies: the Brethren of Purity, al-Ghazali, and Ibn Khaldun.

Three Case Studies

The Brethren of Purity (*Ikhwan al-Safa'*) were a fraternity, whose members are still unknown or insufficiently known, that flourished in Basra in 10th century Iraq. They were, in my view, a Shiite-Ismailite sect, as revealed by the gnostic, mysteriosophic, speculative and allegorical character of their work. Their *Encyclopaedia* (*Rasa'il*) is a veritable *summa* of Medieval Islamic knowledge at its apex, touching upon each and every branch of it: from practical sciences to metaphysics, from zoology to history. The most relevant element of this work is a tripartite classification of sciences: *propaedeutic* (i.e. immediately useful for life, a category encompassing grammar, magic, economy, and historiography), *religious* (concerning Islamic disciplines, such as traditions, law, and symbolic exegesis of the Qur'an), and *philosophical* (arithmetic, logic, physics, natural history, and theology).

This work presents knowledge as vertically ordered towards God; it is clearly and heavily Neoplatonic and Neopythagorean in character, with its emphasis on the correspondence between mankind as microcosm and universe as macroanthropos, as well as on numerology according to which each cipher possesses a complex symbolic and magic value. However, what is most relevant is the Brethren's emphasis on *prophecy* and *secrecy*. History and reality are considered as the result of the cyclical process of revelation, in a net of symbolical and numerological correspondences that can only be mastered by a few initiates who are accurately selected by the Brethren.

Abu Hamid al-Ghazali, "Ornament of Religion and Proof of Islam," theologian and mystic, bitter critic of the philosophers but himself a speculative mind, reproached the Brethren for having tried to demonstrate philosophical positions through arguments touching upon sacred or prophetic matters. In other words, he was against syncretism and wanted to distinguish the different ways towards knowledge, among which he finally emphasized Sufi mysticism without abandoning philosophy. He was always highly appreciative of logical rigour and syllogisms, as well as of mathematics. Nevertheless, at the same time he feared that the latter might have a nefarious influence over simple or

inexperienced minds since, because of its clarity and precision, it could induce them to neglect Islam in favour of philosophy.

In his famous work *The Incoherence of the Philosophers* (*Tahafut al-Falasifa*—later refuted by Averroes in the equally famous *Incoherence of Incoherence—Tahafut al-Tahafut*) al-Ghazali expands on the epistemological value of mathematics as well as of natural sciences in general. He states that mathematics has nothing to do with religion, so that appealing to faith in order to reject its demonstrative conclusions is simply silly. Anybody who referred to the Sacred Text in order to deny the explanation of natural facts that has been attained through reasoning and calculation (for instance the phenomenon of an eclipse) would be even worse than silly—they would be a threat to religion, inducing people to think that Islam opposes intelligence. An acute adversary is better than an ignorant friend! However, natural sciences as a whole, according to al-Ghazali, are intrinsically worthless if compared to theology: investigating, like the philosophers do, whether the world is eternal or created, whether it is round or flat or even hexagonal, how many heavens there are, is tantamount, if compared to the research of God (*al-bahth al-ilahi*), to knowing the number of layers in an onion or seeds in a pomegranate. This judgement is somewhat hasty, but it clearly indicates how the priority of a believer was identified in salvation.

Partly different is the attitude of ‘Abd al-Rahman Ibn Khaldun. Born in Tunis, he lived a tormented and wandering existence among the courts of Spain and of Maghreb until he became professor of Maliki law in Cairo and an appreciated diplomat for the Mamluk sultans. He died in Cairo in 1406. He explained his ideas in the *Muqaddima* or *Introduction* to a universal history (*Kitab al-‘Ibar*). I will not touch upon his political thought (very much pragmatist and even materialist in character) only to examine the place occupied by the sciences in his epistemology[10]. Ibn Khaldun emphasises that the articles of faith are only confirmed by theology. Concerning intellectual sciences he describes them as “natural for man,” defined in his turn as “a thinking being,” and therefore open to investigation and development on the part of people from different religions. The first science is logic, which distinguishes truth and falsity. The second one is the science of perceptible bodies, physics. There follows the science of spiritual essences, or metaphysics. Finally, there are scientific measurements including geometry, arithmetic, astronomy, and music. Medicine is considered by Ibn Khaldun as a prevailing practical art, similar to the work of a tailor or to printing.

Conclusion

When examining the sciences, this author especially emphasises their instrumental character, and when he states his overall judgement towards them the above-mentioned perspective is seemingly turned upside-down. After expressing doubts regarding the objective value of the philosophical doctrines, Ibn Khaldun states that they do not really concern Muslims, nor has physics anything to do with religious or daily matters, so that such fields should rather be left to the philosophers. Ibn Khaldun does not share with al-Ghazali the idea that sciences can be dangerous for religion; but he shares the one

10 Z. Ahmad, *The Epistemology of Ibn Khaldun* (Routledge-Curzon, London and New York, 2003).

according to which they are not necessarily useful for it. Apparently this should be an advantage: one does not run the risk of blending articles of faith and scientific conclusions. However the irrelevance of science compared to religion (also considered as the source of the principles on which society is founded) marginalizes scientific research itself. Ibn Khaldun does understand how Arabic-Islamic society works; he accepts that education is of primary importance, and that natural sciences are relevant for the practical goals of life in society. However he does not consider them as worthwhile and objective as theology or even sociology.

Considering in retrospect the positions, respectively, of the Brethren of Purity, al-Ghazali, and Ibn Khaldun, one cannot fail to notice the absence of any opening or impulse towards a scientific development comparable to the ones brought about by Galileo or Newton. In conclusion Islamic science was *not* the mere vehicle of ancient knowledge for Medieval and modern Europe, and its status only becomes clear if one focuses on the epistemological value of the unity and unicity of God, be it interpreted interpreted gnostically like Nasr does, or ethically-juridically as suggested by Bausani.

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