THE RISE AND FALL OF ISLAMIC SCIENCE: THE CALENDAR AS A CASE STUDY

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Delivered at the conference on "Faith and Reason: Convergence and Complementarity"
At al-Akhawayn University, Ifrane, Morocco June 3, 2002

Introduction

Historically, the scientific dynamism of the classical Islamic society stands as a challenge to the notion that religion and science are inherently approved.

Still, that history also challenges us to answer the question as to why scientific enterprise rose to unprecedented heights among Muslims for hundreds of years, and why it is now so conspicuously absent from contemporary Muslim society. I would like to begin by introducing this audience to the answers I proposed in my book *Signs in the Heavens* and then attempt to support those answers by a demonstration with the case of the Islamic calendar.

Let me first confide in you that I am in the process of writing the second edition to that book, so I may test some ideas that may appear in the second edition.[1]

Islamic Science versus Muslim Science

Before we can discuss the rise and fall of Islamic science, we must ask whether there really is such a thing as "Islamic science." Is it not possible that the great scientific achievements of the classical Islamic civilization were simply "Muslim science," i.e., science done by Muslims, with no religio-cultural characteristics to distinguish it in any meaningful way from science that came before or after? Science is, after all, a process. Do not all scientists, regardless of their religion, go through the same process to arrive at their scientific conclusions?

The answer is no. Greek science differs from modern science in the theory of knowledge that underlies it. The epistemology of Greek science holds that reason alone is sufficient to understand the workings of the universe. In Aristotle's phrase, everything is the way that it is because it could be no other way. If this were the case, then all scientific knowledge could be rationally deduced from self-evident axioms and observation would play no important role beyond a contemplative stimulus to rational thought. Modern science, however, depends upon observations and experiments as well as rational thought in a critical way. In addition, modern science depends on the transmission of accumulated

[1] Passages from chapters 2 and 6 Ahmad (1992), somewhat revised, have been incorporated into this paper.

knowledge through a refereed and properly cited literature. These additional factors evolved during the classical Islamic civilization. Al-Ghazali, who critiqued Greek science for inadmissibly mixing metaphysics with physics in his *Incoherence of the Philosophers*, documented the importance of these additional factors in his *Deliverance from Error*. The three-legged epistemology in which reason, empirical data and authoritative citation check and reinforce one another is the real distinguishing mark of modern scientific methods. This modern method of engaging in scientific research did not emerge mysteriously and instantaneously in the modern West. It had its precursors even in Greek science (Archimedes comes to mind) but evolved into a systematic method of research during the classical Islamic civilization, refined by scholars like al-Biruni, Ibn Haytham, and Ibn ash-Shattir, encouraged by certain Islamic teachings.

Islamic Teachings

We identify seven Islamic teachings as the driving forces behind this development of modern scientific methods that took place in the Islamic civilization:

(1) *Respect for observation.* The Qur'an orders man to observe nature and thus spurs us towards the scientific method of induction.

> Say: "Behold all that is
> In the heavens and on earth";
> But neither Signs nor Warners
> Profit those who believe not.
>
> Qur'an (10:101)[2]

> If there were, in the heavens
> And the earth, other gods
> Besides God, there would
> Have been confusion in both!
>
> Qur'an (21:22)

The contrast between the Islamic view of a nature packed with the signs of God that we are commanded to observe with the Platonic distrust of the senses is unmistakable. Muhammad Iqbal has emphasized that "the general empirical attitude of the Qur'an which engendered in its followers a feeling of reverence for the actual, and ultimately made them the founders of modern science. It was a great point to awaken the empirical spirit in an age that renounced the visible as of no value in men's search after God" (quoted by Siddiqi 1986).

The Qur'an does not see empirical observation, rational thought, and gnostic contemplation as pulling men in different directions. It insists that all lead to God. Thus, we are repeatedly exhorted to "see,"[3] to "think,"[4] and to "contemplate."[5]

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[2] All translations from the Qur'an are from A. Yusuf Ali's (1938) third edition.

[3] "Say: See ye? If God were to make the Day perpetual over you to the Day of Judgment, what god is there other than God, Who can give you a Night in which ye can rest? Will ye not then see?" (Qur'an 28:72)

[4] "Now let man but think from what he is created!" (Qur'an 86:5)

(2) *Universality.* As Islam spread, its universality prevented the Arabs from a crippling disdain for the scientific knowledge of the Greeks, Persians, Indians, Chinese, etc. All good comes from God. This open-minded embrace of knowledge from any source is reflected in the Islamic proverb advising the Muslims to "seek knowledge even unto China" (Azizullah 1972). One exemplary case of how the Prophet himself applied this principle was when he ditched his own plans for the defense of Medina in order to adopt a plan to dig a trench around the city, put forward by Salman-al-Farsi. This was a technique that the Persian Salman had picked up in his homeland and was hitherto unknown in Arabia. The Prophet judged the suggestion by its merits, not by the nationality of the proposer. This objectivity about the sources of knowledge is, of course, merely an extension of Islam's more general principle of brotherhood:

> O mankind! We created
> You from a single (pair)
> Of a male and a female,
> And made you into
> Nations and tribes, that
> Ye may know each other
> (Not that ye may despise
> Each other)….
>
> Qur'an (49:13)

The expanding Muslim civilization was "the first to give science the international character which we consider one of its fundamental characteristics" (Taton 1963).

(3) *Absence of a priesthood.* The abolition of the priesthood and prohibitions of secrecy prevented scientific knowledge from becoming the property of an elite. Knowledge was available to everyone. In the Christian world, people went to the church for religious instruction only. Even that instruction was a "lay" instruction, fit for the layman. Reading of the Bible itself was discouraged for those not initiated into the priesthood. The subtle doctrines of Christian theology might confuse the layman and weaken his faith. It was better to provide him with pre-digested teaching.

By contrast every Muslim was expected to read and preferably memorize the Qur'an. (The very first word of the Qur'an revealed to Muhammad was the commandment "Read!") All knowledge was considered sacred and people came to the mosque to study not only the Qur'an and the traditions, but mathematics, history, natural science, etc. As the numbers of teachers and classes exceeded the space in the mosque, additional buildings would be added around it. Thus, the world came to know its first modern universities.

Terms coined in that era are still in use today. The teachers would sit in low chairs with the students gathered on the carpeted floor around them. A new student interested in learning, say mathematics, could walk into the mosque and ask, "Where is the chair of mathematics?" or "Where is the chair of astronomy?"

(4) *Material success.* A materially successful society can afford to support pure science. Other previous societies that had enjoyed some degree of prosperity had also

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[5] "... contemplate the (wonders of) creation in the heavens and the earth, (with the thought): 'Our Lord! not for naught hast Thou created (all) this!'" (Qur'an 3:191)

supported science. The prosperity under Islam, however, was *unprecedented*, especially given the way it was spread throughout almost all layers of society. Before Islamic civilization had reached its second century, patronage of the arts and sciences had reached new heights.

(5) *Academic freedom.* Academic freedom, necessary for science to move forward, was inherent in the Islamic idea of individual responsibility. The Qur'an advises man that God is "nearer to him than (his) jugular vein" (50:16), that "no bearer of burdens can bear the burdens of another" (53:38), and "Whoever works any act of righteousness and has faith,–his endeavor will not be rejected: We shall record it in his favor" (21:94). As everyone is directly responsible to the Creator, and the priesthood is abolished, disputes are to be resolved not by human authority but by truth–whatever God may have decreed it to be.

The Western Church's interference into scientific matters was based on what was perceived to be a threat to the religion. In Islam, even matters of religion are not exempt from frank and honest discussion. Consider this excerpt from a letter of Hashimi, a cousin of the Caliph Ma'mun, to a religious opponent:

> ... bring forward all the arguments you wish and say whatever you please and speak your mind freely. Now that you are safe and free to say whatever you please appoint some arbitrator who will impartially judge between us and lean only towards the truth and be free from the empery of passion, and that arbitrator shall be Reason, whereby God makes us responsible for our own rewards and punishments. Herein I have dealt justly with you and have given you full security and am ready to accept whatever decision Reason may give for me or against me. For "There is no compulsion in religion" (Qur'an 2:256) and I have only invited you to accept our faith willingly and of your own accord and have pointed out the hideousness of your present belief. Peace be with you and the blessings of God!
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> (Arnold 1913)

(6) *Development of principals of proper citation.* The natural sciences in Islam had a model in the development of the religious sciences as to proper citation and investigation of the credibility of sources. The early Muslims, like the early Christians, had to contend with a plethora of "traditions" attributed to the religion's founder. The Christians relied on the authority of a central Church (backed by the state) to resolve the issue. Having no priesthood, the Muslim scholars invented new techniques of historical scholarship.

Scholars such as Imams Bukhari and Muslim went on long expeditions to track down traditions (called hadith) attributed to the Prophet's companions to their sources. They determined the complete chain of transmission from the Prophet's companion to the particular reporter whom they were able to find. They made biographies of every transmitter in the chain to determine their reliability for honesty, soundness of memory, plausibility of having met adjacent members in the chain of transmission, etc. Thus, Muslim historians became accustomed to the process of *citation*, something that is an indispensable part of modern science. The vagueness of ancient historians about their sources stands in stark contrast to the insistence that scholars such as Bukhari and Muslim manifested in knowing every member in a chain of transmission and examining their reliability. They published their findings, which were then subjected to additional scrutiny by future scholars for consistency with each other and the Qur'an. By the third century of Islam this methodology was well developed.

Such open "historical criticism" of the Islamic traditions is a process to which Christian texts have been subjected only in recent centuries. It is a process of analysis and preservation in the form of a *scientific* study. Hadith science was original with Islam. It was the first uniquely Islamic science and provided a precedent for open and rigorous scholarly debate in the natural sciences that were being assimilated into the emerging Islamic culture.

(7) *Emphasis on learning and study.* From the very first word of the Qur'an revealed (*Iqra!*, which means "Read!"), praising the "Lord who taught man by the pen," the Qur'an (96:1) emphasizes learning and study in all its aspects. Qur'anic teachings on the importance of knowledge to religion and the pointing out of the signs of God in the heavens and on earth provided an incentive for the patronage of science.

> It is He Who created
> The Night and the Day,
> And the sun and the moon:
> All (the celestial bodies)
> Swim along, each in its
> Rounded course.
>
> Qur'an (21:33)

The Muslim World Today

What is the status of these factors in the Muslim world today?

(1) *Induction*. The persistent confusion over the Islamic calendar shows that there is an inadequate understanding of induction in the Muslim world. The insistence on requiring actual moonsightings and then uncritically accepting false reports suggests the crudest sort of *empiricism*.

(2) *Universality*. Any renaissance of Islamic science will require the critical incorporation of modern Western knowledge into the new Islamic knowledge, just as the early Muslims freely evaluated numerous foreign bodies of knowledge. Today's Muslims have not yet demonstrated that they accept this. Instead, there is still an undertone of feeling that everything in the West is bad and must be rejected *in toto*. No greater insult can be hurled by one Muslim against another than to say: You have been influenced by the West. Yet, in some important respects, America is more true to Islamic principles than some self-righteous societies in the Muslim world–not least of all in science.

(3) *Absence of a priesthood*. Iqbal's call for reopening the door to *ijtihâd*–to "all qualified Muslims and not just the *ulama* (Esposito 1988, pp. 142-143) has not yet been heeded. With political power concentrated in the hands of a few, an elite group of jurists or clerics in their pay dictate how God's commands are to be applied to the modern world, and what knowledge may be pursued and what may not. This is effectively a priesthood as far as the prospects for scientific progress are concerned.

(4) *Material success*. In the presence of the glorification of asceticism and, often, in the absence of economic freedom, the material prosperity that allows the support of pure scientific research is not possible. To the degree that Muslims take pride in their poverty, they have a disincentive against its alleviation.

(5) *Academic freedom*. The discussion in the previous chapter is only the tip of the iceberg regarding the paucity of academic freedom in the Muslim world.

(6) *Citation*. I have already addressed this subject at length, but let me add one more example to drive home the point that proper citation has become a lost art. There is a book called *Glimpses of the Hadith* (Azizullah 1972) that goes into great detail describing the care early hadith compilers took in citing their sources. The author, however, concludes with a lengthy list of alleged hadith for which he gives no citation whatsoever! In fact, some of them are not authentic hadith at all and the collection must be considered merely a compilation of Islamic proverbs. To determine which are authentic hadith would require what would be practically an original research effort on the part of the reader. In contrast to the early hadith compilations, this provides a poor model for scientific citation.[6] Modern Muslims appear to fear that critical examination of hadith literature will threaten long-cherished beliefs. The scientific model is to be ruthlessly critical in the hopes that any error, its longevity notwithstanding, will give way to truth.

(7) *Emphasis on learning and study*. This is the one area where attitudes are beginning to change. Unfortunately, the motivation seems to be the ignoble one of envy of the West's greater imperial power. I have met many students from Muslim countries and their attitude is too often a desire to learn engineering and urban planning but to avoid getting contaminated by any notions of independent or original thought. This will not do. Scientific progress does not consist of mere imitation of the products of technology. Learning and study must include a reopening of *ijtihâd*. Scientific research will require total freedom of thought, experiment, and discussion: all of the elements of induction.

Turning Away from Ijtihâd

After praising mathematics, logic, and Sufism, al-Ghazali attacked what he characterized as the fourth branch of science:

> The fourth subject is Physics of which some portions contradict the Shariat and true religion and thus are not right.
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> Al-Ghazali (1106-1111a, vol. 1, p. 39)

Aristotelian physics, which postulated two sets of laws instead of one for the universe, certainly contradicts the Qur'an and is also certainly not right. Yet, how can one, on the face of it, distinguish al-Ghazali's statement from the Catholic Church's objections to Bruno? Al-Ghazali's profound statement was not understood in the way most conducive to the continued progress of Islamic thought. It could have been the spur to a revolutionary physics such as we have seen in modern times. Instead, it was part of a legacy which closed the door to *ijtihâd* and to innovative Islamic thought.

> The decline of science inside a great culture is in itself a fascinating study and a great object lesson. ... al-Ghazzâlî's famous eloquence ... went to building up the whirlwind of intolerance and blind fanaticism which tore down not only science

[6] It does, however, follow the pattern of Al-Ghazali. While I think that Ghazali's anti-rationalism has been unfairly exaggerated, his habit of attributing quotations to the Prophet without citing his sources set a very bad precedent. The willingness of the Muslim community to accept these unsubstantiated attributions is yet another signal of the incipient decline of Islamic science coincident with Al-Ghazali's influence

> but the very School system and the glorious *ijtihâd*....
>
> de Santillana (1966)

It is ironic, given Sufism's emphasis on the primacy of spirit above legality, that in the aftermath of al-Ghazali's efforts Islamic jurisprudence was robbed of its dynamic element. *Ijtihâd*, the individual struggle for understanding, was replaced by *taqlîd*, blind imitation of the past.

> Islamic law, the product of an essentially dynamic and creative process, now tended to become fixed and institutionalized. While individual scholars like Ibn Taymiyya (*d*. 1328) and al-Suyuti (*d*. 1505) demurred, the majority position resulted in traditional belief prohibiting substantive legal development. This is commonly referred to as the closing of the gate or door of *ijtihâd*. Belief that the work of the law schools had definitively resulted in the transformation of the Sharia [Islamic law] into a legal blueprint for society reinforced the sacrosanct nature of tradition; change or innovation came to be viewed as an unwarranted deviation (*bid`a*) from established sacred norms. To be accused of innovation–deviation from the law and practice of the community–was equivalent to the charge of heresy in Christianity.
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> Esposito (1988, p. 85)

Aversion to innovation is, of course, fatal to science. By the fifteenth century the effect of the closing of the door to *ijtihâd* on scientific progress in the Islamic world was unmistakable.

Problems of the Lunar Calendar

The Islamic calendar poses an interesting case for the illustration of these concepts because of the centrality of a calendar in the life of any civilization. There can be no doubt that the desire to predict seasonal patterns through their correlations with the motions of the celestial bodies is one of the major forces urging pre-scientific peoples to develop scientific understanding. For decades, Archeoastronomers have attempted to demonstrate the relationship between ancient structures like Stonehenge and calendar-related issues.

In the case of the Muslims, their religious calendar is a strictly lunar calendar. Traditionally all dates are based on a twelve-month year with the beginning of each month calibrated to sightability of the new moon crescent. Such a calendar will have a year of 354 or 355 days. The pre-Islamic Arabic calendar had been a luni-solar calendar. It was also calibrated by sighting of the new crescent, but occasional leap months were inserted in order to keep the calendar in sync with a solar year of approximately 365.25 days.

The problem with the pre-Islamic calendar was that there are four sacred months under which warfare is prohibited. The decision whether or not to insert a leap month in a particular year could alter the months during which fighting was permitted. The pagan Arabs had allowed military consideration to be the determining factor in when they

would insert the leap months. This practice was prohibited in the Qur'an and as a result, intercalation was banned by the Muslims leaving the strict lunar calendar.

One might think that the prohibition of intercalation would cause a serious problem for the Muslims, for example in areas like agriculture. How can a farmer know when to plant his crops when his calendar is divorced from the seasonal cycle? In fact, the prohibition only resulted an incentive for the development of more sophisticated tools for the tracing of dates. Instead of printing simple calendars which would suffice for determining planting and harvest times had the calendar been solar, one of the first Muslim scientific accomplishments was the printing of tables predicting the probable weather conditions from the climatic impact of the earth's position in its orbit, much as their descendent The Old Farmers' Almanac does today. (The word "almanac" comes from the Arabic *al-manâkh* which means climate.) These almanacs were the beginning of Islamic science.

The real challenge for the Islamic calendar was not the absence of intercalation, which really only simplified the problem, but rather the difficulty of predicting when the new moon could be seen. The astronomical new moon (the moment when the moon crosses from one side of the sun to the other as it orbits the earth) is too close to the sun to be seen for a variety of reasons. Primarily, the lit side of the moon is then facing the sun, away from the earth. The moon will not be visible until it sets after the sky has become dark enough for the moon's faint light to exceed that of the background sky. Determining that time is one of the most complex problems of classical astronomy.

To some degree this problem had been solved by pre-Islamic astronomers, and the Muslims learned of those solutions from the translation movement and further refined the techniques (Ilyas 1997). In the 8th century Yaqub ibn Tariq produced tables for calculating sightability and Habash developed a calculation system. In the 9th century al-Khwarizmi (who is most famous for his book on algebra and from whose name the words "algorithm" and "logarithm" are derived) devised a method for predicting visibility based on the "arc of light" or the elongation of the moon from the sun. In the same century al-Battani and al-Farghani developed refinements to the ancient methods of using the time of moonset after sunset in the special case where the arc of light was large. Many others (including non-Muslims working in the Muslim civilization like Thabit ibn Qurra and Moses Maimonedes) followed.

To engage in such refinements one needs more than mathematics and rational analysis. One needs reliable reports of the earlier work on which one is building and empirical data on which to build the refinements. Muslims developed great observatories with huge libraries for just such a purpose. Among the researchers on the calendar problem, for example, was Nasir ad-Din Tusi, director of the great 13th century observatory at Maragha that boasted not only the most advanced observational equipment until Tycho Brahe's famed 16th century observatory, but a library of 400,000 books and an international staff (including a Chinese astronomer).

The role of the seven factors in Islam mentioned above in the development of the lunar calendar are self-evident. The question is then how has the falling away from these factors affected the calendar problem in Muslim society today?

There are certain parts of the Muslim world, for example in Pakistan, where actual sightings are attempted by the masses, guided by astronomical calculations of the most likely times of sightability. Most American Muslims, however, simply call relatives in their home countries and accept hearsay reports that some unidentified person has seen the moon somewhere. In Saudi Arabia large cash awards offered for first sighting, with no restrictions based on astronomical theory, have resulted in a situation in which one of a handful of people from the same locations repeatedly claim the award almost invariably on sightings impossible according to astronomical theory and often on dates preceding the physical occurrence of the astronomical new moon (Shaikh 2000).

Rather than induction, today's Muslims employ an extremely crude empiricism. Attempts by Muslim astronomers to explain why the crescent cannot be sighted before the new moon are rebuffed by the masses on the grounds that the "western" defined new moon is not an Islamically defined concept–ignoring it is simple universal fact that a new crescent cannot be seen before an astronomical new moon and not simply a matter of definition. The failure of the Muslims community to question the Saudi establishment's acceptance of impossible sightings bestows a quasi-priestly sanction to the role of the Saudi government. Of course, the absence of academic freedom is a contributing factor to that failure. The reliance on hearsay demonstrates the degree to which proper citation has fallen out of favor. The fact that there are so few Muslims astronomers and that the ones who exist are so ignored attests to the collapse in the emphasis on learning and study.

The one factor that seems to play no role in all this is the matter is that of material success. The Muslims have the material resources to solve this problem. Not only have they not elected to use their vast material resources to produce, for example, an orbiting lunar observatory that could conclusively resolve all doubts about moonsighting (while at the same time bringing forth a rebirth of eminence in astronomy), they have not even expended the mere thousands of dollars it would take to produce a reliable 100-year calendar of Islamic dates based on any of the scientifically valid models advocated by a variety of Muslim astronomers. A contributing factor to this failure may be the anemia of free markets in the Muslim world, but that cannot account for the failure of, for example, American Muslims to fill the gap.

Conclusions

Science is a process. The constraint of a strict ban on intercalation need not be an obstacle to science, provided the seven mandates are in place. Those seven mandates support science, indeed provide a skeleton on which the "scientific methods" of the process fit.

The danger to conservative or traditionalist religionists that their interpretations of scriptures may be challenged is not an argument for separation of religion and science, but for the submission of interpretation of scripture to critical thought. God is not less author of the universe than of the Qur'an. The replacement of Newton's theory of gravity by Einstein's demonstrates not that God made an error in designing gravity, but that Newton's understanding of gravity was less complete than Einstein's. Similarly, when any interpretation of scriptures becomes untenable in the face of greater understanding, it is only the fallibility of men that need to be called into account. The resolution of the calendar problem is a case in point.

Whatever its disposition, the moon will continue to orbit the earth as God intended.

Allahu a`lam (God knows best).

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