

REFLECTIONS ON SOME NEW STUDIES ON APPLIED SCIENCE IN ISLAMIC SOCIETIES (8TH-19TH CENTURIES)

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Recent research on Arabic scientific and legal manuscripts, as well as on astronomical instruments, has led to a new understanding of the different ways in which Muslim scholars over many centuries applied scientific methods to determine the times of prayer and the sacred direction (*qiblah*).

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Muzaffar Iqbal kindly invited me to pen a few thoughts for this journal as I see through press the third of four books dealing with aspects of applied science in Islamic civilization. I have been fortunate enough to work in manuscript libraries and museums all over the world for over 30 years, and these books are the main fruits of this enterprise. (Believe me, the frustrations of such activities and the attendant discomforts sometimes outweigh the pleasures.) The books, I would maintain, deal with topics of fundamental importance to the history of Islamic civilization, yet these topics have not been dealt with previously, because only a very few unrepresentative sources had been unearthed.

Both Muslim scientists and Muslim legal scholars addressed what I have called “science in the service of Islam”, that is:

- (1) the regulation of the strictly lunar Muslim calendar;
- (2) the organization of the times of prayer; and
- (3) the determination of the sacred direction (*qiblah*) towards the Ka‘bah in Makkah.

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These new books supplement my three volumes of Variorum reprints published a few years ago and dealing mainly, but not exclusively, with these same three topics.¹ All of my studies clearly distinguish between:

- (1) the *scientific tradition* pursued by the select few in Islamic societies,² and
- (2) the *folk scientific tradition* (devoid of any mathematics beyond simple arithmetic and of any astronomy other than what can be observed with the naked eye) favored by the legal scholars of Islam.³

An appreciation of the dichotomy between the approaches of the scientists and the legal scholars is essential to an understanding of why scientific activity flourished for so long, but also eventually declined, in Islamic societies. This is never mentioned by anyone who has written on the nature of science in the Islamic world, let alone on its decline. It is also important for the notion of “Islam and Science” or “Science in Islam”, for when Muslim scientists, using mathematics, addressed problems provided by the tenets of Islam, they came up with completely different solutions from those proposed by the legal scholars, who used the *Qurʾān* and the *ḥadīth*, together with the simple procedures of folk science. For a modern example, consider the two schools of North American Muslims regarding the *qiblah*: one group maintains it is north of east in North America (based on geography and mathematics) and the other favor south of east (based on a naïve

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1. *Islamic Mathematical Astronomy* (London: Variorum, 1986, 2nd rev. edn., Aldershot: Variorum, 1993); *Islamic Astronomical Instruments* (London: Variorum, 1987, repr. Aldershot: Variorum, 1995); and *Astronomy in the Service of Islam* (Aldershot: Variorum, 1993).
 2. David A. King and Julio Samsó, with a contribution by Bernard R. Goldstein, “Astronomical Handbooks and Tables from the Islamic World (750-1900): An Interim Report” in *Suḥayl—Journal for the History of the Exact and Natural Sciences in Islamic Civilisation*, Barcelona, 2 (2001), pp. 9-105.
 3. For overviews see Daniel M. Varisco, “Islamic Folk Astronomy” in Helaine Selin, ed., *Astronomy across Cultures—The [!] History of Non-Western Astronomy* (Dordrecht, etc.: Kluwer, 2000), pp. 615-50 and David A. King, “Folk Astronomy in the Service of Religion: The Case of Islam” in Clive L. N. Ruggles and Nicholas J. Saunders, eds. *Astronomies and Cultures* (Niwtot: University Press of Colorado, 1993), pp. 124-38.

modern kind of folk geography).

In the sequel, I shall briefly describe the contents of each of the new books. I shall also discuss the problem that, because of the nature of the transmission of knowledge these days, this flurry of new books on practical aspects of Islamic ritual and scientific highlights of Islamic civilization will probably never reach a serious Muslim scholarly audience in the form that I am publishing them.

The first book, entitled *World-Maps for Finding the Direction and Distance to Mecca* and published in 1999, examines the way in which Muslim scholars for over a millennium dealt with the determination of the *qiblah*.⁴ Here we witness the ingenuity of scientists from the 9th to, say, the 15th century, as they confronted a complicated problem of mathematical geography: their results are impressive by any standards. A large part of the book is devoted to a detailed study of two remarkable newly-discovered world-maps from Şafavid Iran (late 17th century) fitted with a cartographical grid so devised that one can simply read the direction and distance to Makkah at the centre. In the book, I hypothesized that the brilliant idea underlying the grids on the maps must go back to earlier (9th or 10th century) Islamic sources, which alas I had been unable to locate (though see below). I had, however, investigated numerous Şafavid works, finding them all lacking the kind of initiative in evidence behind the map grids, and I also considered the possibility of influence from European sources, with negative conclusions. This book was published in the series *Islamic Philosophy, Theology and Science: Texts and Studies* by Brill Academic Publishers, with a subvention from the Al-Furqan Islamic Heritage Foundation that made it affordable. Muzaffar Iqbal reviewed the book and the underlying methodology favorably in the first issue of this journal,⁵ although he found me incapable of penetrating “the realm where the Islamic scientific tradition is perceived in its totality with all its integral links to the metaphysical doctrines of Islam intact”.

The second book, *The Call of the Muezzin*, is available from E. J. Brill as of January, 2004. It contains a comprehensive collection of essays devoted to astronomical timekeeping by the sun and stars and

4. *World-Maps for Finding the Direction and Distance to Mecca: Innovation and Tradition in Islamic Science* (Leiden: E. J. Brill and London: Al-Furqan Islamic Heritage Foundation, 1999).

5. *Islam & Science* Vol. 1 (2003) No. 1, pp. 135-42.

the determination of the times of Muslim prayer, as practiced in Islamic societies for over ten centuries.⁶ A large part of this book—written already in the 1970s—deals with tables for time-keeping by the sun and stars and for regulating the times of prayer; it is based on over 500 manuscripts that nobody had ever looked at previously in modern times. The materials come from all over the Islamic world from Fez to Yaqand and from Crete to Taiz. The book also contains sections on the origins of the definitions of the times of prayer that became standard (but which are not specifically mentioned either in the *Qurʾān* or the *ḥadīth*), on the simple methods for timekeeping that were used by the scholars of the sacred law, and on the activities and social status of the muezzins and muwaqqits. Since no sponsor could be found for this book, it will sell at four times the cost of the first.

In my first book, I had hypothesized the existence of an early Islamic tradition of Makkah-centred world-maps, of which the two Ṣafavid examples were the sole surviving evidence. In the second book, I present a third Ṣafavid map of the same kind. I also present evidence, discovered by my colleague Jan Hogendijk of Utrecht, that Muslim scientists in the 10th century (Baghdad) and 11th century (Isfahan) had discussed the solution of the *qiblah* problem using ellipses, such as are found (sensibly approximated by arcs of circles) on the Ṣafavid maps. This should quieten those ungenerous colleagues in the history of European astronomy and cartography who preferred to see European initiative behind the Ṣafavid world-maps.

The third book, entitled *Instruments of Mass Calculation*, deals with astronomical instruments from the Islamic world and is to appear with E. J. Brill later in 2004.⁷ I coined this title because we searched for such instruments in Iraq, and indeed all over the Islamic world, and we found enough evidence to prove that Muslim astronomers had serious programs of instrumentation from the 8th to the 19th century. My book is my contribution to the “war against ignorance”. It reveals for the first time the range and sophistication of the long and rich tradition of Islamic astronomical instrumentation. It was already well

6. *In Synchrony with the Heavens—Studies in Astronomical Timekeeping and Instrumentation in Islamic Civilization*, 2 vols., vol. 1: *The Call of the Muezzin. Studies I-IX*, (Leiden: E. J. Brill, 2004).

7. *In Synchrony with the Heavens—Studies in Astronomical Timekeeping and Instrumentation in Islamic Civilization*, 2 vols., vol. 2: *Instruments of Mass Calculation. Studies X-XVIII*, (Leiden: E. J. Brill, 2004).

known that *medieval* European instrumentation was highly indebted to the Islamic tradition, but now it is clear that *only after* ca. 1550 did European instrument-makers make technical innovations that had not been known to Muslim astronomers previously. This comes as quite a surprise to colleagues who work on Renaissance European instruments.⁸ My book includes an essay on the earliest known astrolabe, from 8th-century Baghdad, which at least until the 2003 invasion of Iraq, was housed in the Archaeological Museum in Baghdad. (I have no idea where it is now.) It continues with a description of all known astrolabes from late-9th- and 10th-century Baghdad, some 13 in number, taken from my unpublished catalogue of medieval Islamic and European instruments. I also include an essay showing that the idea behind the most sophisticated instrument of the Renaissance, the universal horary dial for finding time *by the sun* for any latitude, is most probably of early Islamic origin. Although I did not find precisely this instrument mentioned in Arabic texts, I did locate some years ago a treatise on a more complex instrument for the more difficult problem of timekeeping *by the stars* from 9th-century Baghdad.⁹ Certain colleagues in the history of European astronomy have accused me of indulging in a kind of cultural contest, and I have to admit to a certain amount of pleasure in establishing that various instruments previously thought to be European inventions were actually invented by Muslim astronomers centuries previously.¹⁰

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8. See my review of Gerard L. E. Turner, *Elizabethan Instrument Makers—The Origins of the London Trade in Precision Instrument Making* (Oxford: Oxford University Press, 2000) in *Journal of the History of Collections* (Oxford) 15:1 (2003): 147-50, especially pp. 149-50.
 9. François Charette and Petra G. Schmidl, “A Universal Plate for Timekeeping with the Stars by Ḥabash al-Hāsib: Text, Translation and Preliminary Commentary” in *Suhayl—Journal for the History of the Exact and Natural Sciences in Islamic Civilisation* (Barcelona) 2 (2001): 107-59.
 10. For these colleagues I have published summaries of the discoveries outlined in *Instruments of Mass Calculation* (see note 6), XIIa and XIIb, separately in “A *Vetustissimus* Arabic Treatise on the *Quadrans Vetus*” in *Journal for the History of Astronomy* 33 (2002): 237-55, and “14th-Century England or 9th-Century Baghdad? New Insights on the Origins of the Elusive Astronomical Instrument Called the *Navicula de Venetiis*” in *Centaurus* 44 (2003): 204-26.

At this stage, I should mention that my young colleague, François Charette, has just published a major contribution to our understanding of Islamic instrumentation. For some years now we have known of the existence of a treatise by an enigmatic Egyptian scholar Najm al-Dīn al-Miṣrī (*ca.* 1325), in which he describes and illustrates over 100 different instrument types known to him or invented by himself. Charette has published a model edition and translation of this complicated treatise, together with a detailed commentary.¹¹ There is a sense in which his book provides a kind of “instant supplement” to my new book on instruments.

The fourth book, *The Sacred Geography of Islam*, was written in the 1980s but never published:¹² I was on the point of submitting it to a publisher in 1989 when the first of three Ṣafavid Makkah-centred world-maps showed up and absorbed my attention for several years. What I mean by “sacred geography” is the notion of the Ka‘bah at the centre of the world, and the way sectors of the world are organized around the sacred edifice. Various Muslim scholars of folk astronomy, geographers, and legal scholars discussed this notion, and their schemes of the world about the Ka‘bah are often illustrated. In these schemes, the *qiblah* in each region is defined in terms of the risings and settings of the sun and various bright stars. The *qiblah* for each region is inevitably different from the values derived by Muslim scientists. Some 20 different schemes of sacred geography recorded in some 30 different sources are described in this book. I hope to submit the manuscript to Brill this autumn.

So why did I write these books? They mark the culmination of my preoccupation for over 30 years with the primary sources of the history of Islamic science. I worked on these because I found them exciting and rewarding. It was my firm conviction 30 years ago that this was the least researched area of the history of Islamic science, though colleagues who work on the history of Islamic mathematics, cosmography, optics and medicine could actually make similar claims for their chosen fields. I write primarily as an Islamicist rather than as

11. François Charette, *Mathematical Instrumentation in Fourteenth-Century Egypt and Syria—The Illustrated Treatise of Najm al-Dīn al-Miṣrī* (Leiden: E. J. Brill, 2003).

12. *The World about the Ka‘ba—The Sacred Geography of Islam*, to be submitted to E. J. Brill.

a historian of science, since my interests in the field of Islamic Studies are broad, but my activities in the History of Science are restricted to the Islamic period and the European Middle Ages. Muzaffar Iqbal called me a positivist, and I was happy to show this remark of his to my wife, who finds me too “negativist” on a variety of issues.

Is it so bad to be a positivist? What it means to me is being involved in the old “Quellen und Studien” approach to cultural history: find a source and publish a description of it that captures the essence of what was intended by the original compiler. (I am well aware that some colleagues are positivist to the point of being petty and essentially irrelevant to any undertaking beyond filling the pages of very boring scholarly journals.)

Take the case of a 14th century Muslim scholar who compiled a table displaying the *qiblah* in degrees and minutes for each degree of latitude and longitude difference from Makkah to serve the entire Muslim world. The table was investigated for the first time in 1970. Before that time, it was not known that Muslim scientists compiled such tables. What greater tribute to that early scholar’s brilliant achievement than to edit his table from the available manuscripts, reconstruct the original values where they have been distorted by copyists, and provide the cultural and historical context for the table? Most of the entries are so accurately computed (with no errors in the minutes) that we have still not been able to determine the procedure whereby they were originally computed.

If this is “positivism” on my part, then it is in order, for at least the achievement of the original compiler has been saved from oblivion, and others now have access to it.¹³ He compiled this table not only because he was a Muslim but because he was a mathematician and a Muslim. In fact, he was one of the leading mathematicians anywhere in the world at the time. Other approaches to such a *qiblah* table, such as art-historical or palaeographical—“the table is framed in a ...” or “the entries are written in a dark brown ink ...”—can only be labeled inadequate. Another copyist may have preferred ink of a different color. The apologetic approach—“with such tables, Muslims were able to face the *qiblah* correctly for over a millennium ...”—is superficial and also historically incorrect, for, in fact, the table was known only in

13. King, “al-Khalili’s Qibla Table” in *Journal of Near Eastern Studies* 34 (1975): 81-122, repr. in *idem, Islamic Mathematical Astronomy*, XIII.

a very restricted geographical and chronological milieu. Contemporaneous legal scholars were proposing completely different means for finding the *qiblah* anyway and would never have considered using a table for that purpose. It happens that we now know of nine different tables displaying the *qiblah* for each degree of longitude and latitude in the Muslim world, the first of which dates, inevitably, from ninth century Baghdad. Nevertheless, the often curious orientations of medieval mosques in each region of the Muslim world prove that scientists were seldom consulted on the *qiblah*. Many of these orientations are of the kind proposed in the medieval schemes of sacred geography. All of these orientations are towards the *qiblah*: it just depends what procedure was used to determine the *qiblah*. (Much nonsense has been written by historians of Islamic architecture who have noticed that this or that mosque did not face the direction they thought it should.)

Why did I publish these books with Brill? First, their *Islamic Philosophy, Theology and Science* series has produced already 55 volumes since its inception around 1990. Second, I have a long association with Brill through my contributions to their monumental *Encyclopaedia of Islam*. Some Muslims seem to find the *Encyclopaedia* problematic; it is indeed written from an objective, “positivist” if you like, point of view, if one can credit orientalists—see below—with objectivity. Anyway, like it or not, it is the basic (and only) reference work on Islamic civilization in all its facets. Interested readers who cannot access my books will at least find there my survey articles such as “Qibla” on the sacred direction of Islam; “Makka, As centre of the world” on sacred geography; “Miqāt” on astronomical timekeeping and the regulation of the times of prayer; “Samt” for the first mention of Makkah-centered world-maps; and on various categories of instruments: “Mizwala” on sundials; “Rubʿ” on quadrants, “Shakkāziyya” on universal instruments; “Ṭāsa” on the magnetic compass; and “Zīdj” (with Julio Samsó) on astronomical tables. All of these supplement the earlier and long out-of-date article “Aṣṭurlāb” on astrolabes. There is one further reason why I publish with Brill: their editors do not mess about with my text, and their printers know what they are doing, a rare combination these days.¹⁴

14. I am sick and tired of editors who mess up texts – for example, by inserting bibliography into footnotes, of translators who have no

What will happen to these books of mine? They will automatically reach the major national and university libraries that subscribe to the Brill Series, as well as the libraries of some centers for Near Eastern Studies or History of Science. Some copies will end up in the private libraries of colleagues in those two fields. A few of these will have received free copies for reviews in the major journals of these two disciplines. And by the time any Muslim scholars outside the Western world hear about them and their contents—we are talking about the first histories of *taḥdīd al-qiblah* and *taḥdīd mawāqīt al-ṣalāt*—the books will be out of print and will have become collectors' items. It's rather sad, but the same is true of most publications on the history of Islamic science over the past 50 years.

Modern Muslim scholars who write on Islam and science generally have no idea of what a small group of scholars of diverse nationalities, including Arabs, Iranians, Turks and Indians, has achieved in the past 50 years. There are journals devoted almost entirely to new discoveries in this field: *Journal for the History of Arabic Science* (Aleppo), *Suḥayl—Journal for the History of the Exact and Natural Sciences in Islamic*

idea what they are translating, and of printers who mess up edited texts because they do not respect the authors' requests. The worst example I can cite is an article on "Science in the Service of Islam" that I was invited to submit to UNESCO's scientific journal *Impact of Science on Society* in 1991, and which was to have appeared in various languages. First, the editors removed all of the direct quotes from the *Qurʾān* and the (Sunnī and Shīʿī) *ḥadīth*. This enabled the person who was entrusted with the preparation of an Arabic translation to add a series of footnotes to the effect that "the author does not seem to know that in the *Qurʾān*...". The translator further did not recognize one *ḥadīth* I had cited, which happened to be a Shīʿī *ḥadīth* (and had been clearly identified as such in my original paper), and he consequently accused *me* of fabricating it! He also converted all dates in my text as though they were Hijra dates, so that Cairo became founded in 969 H or 1561. The disastrous Arabic translation was fortunately withdrawn and never published. Thus the first account of "Science in the service of Islam" was published in English, French, Portuguese, Chinese and Korean, and since then also in German, Italian and Persian, but not in Arabic. Also worthy of mention is an English printer entrusted just last year with an article heavy on Arabic transcription: he succeeded, it is not clear how, in converting half of each batch of long vowels to a different long vowel, so that the entire lot had to be corrected *individually by hand*.

Civilisation (Barcelona), *Arabic Science and Philosophy* (Cambridge), *Zeitschrift für Geschichte der arabisch-islamischen Wissenschaften* (Frankfurt), *SCIAMVS—Sources and Commentaries in Exact Sciences* (Kyoto), and now *Islam & Science*. For an overview of what is being done I can recommend the website: www.ou.edu/islamsci/

There are many websites set up by well-meaning but poorly-informed Muslim student groups at various Western universities that are an insult to the splendid achievements of the Muslim scientists of the Middle Ages. They are invariably based on sources that are decades out of date. In fact, I do not know of one that is well informed or realizes that *the history of Islamic science is a subject that is still being researched*. In order to remain sane during the 2003 invasion of Iraq I compiled a bibliography of writings on the exact sciences in Baghdad during the 8th-10th centuries.¹⁵

I have mentioned above the designation “orientalist”, a word that has become tainted by modern savants who have no conception of what most orientalists actually do. Their criticism of orientalists focused on some of the “bad guys”, of whom, I admit, there were a few with their own dubious agendas. The vast majority of orientalists I know, however, have a healthy respect for the cultures they study. Those working in the history of Islamic civilization often have knowledge of other cultures, be they Classical, Byzantine, Indian, Jewish, Sasanian, or whatever. These insights help them to see Islamic civilization in a clearer perspective than those who know only the Islamic one. Certainly, when dealing with Islamic science, it helps to have a foundation in Greek, Indian and Sasanian science.

A curious situation arose decades ago when historians of science, interested primarily in the early history of Western science, perceived Islamic science solely as an agent for the transmission of superior Greek science to eager but still ignorant Europeans in the Middle Ages. Or, to put it another way, they were only interested in Islamic works that were transmitted to Europe. Now the astronomical works of, say, al-Khwārizmī (Indian and Sasanian influence) and al-Battānī (Greek influence), and the mathematical works of the same al-Khwārizmī (essentially Babylonian algebra and Indian arithmetic),

15. See http://www.uni-frankfurt.de/fb13/ign/astronomy_in_baghdad/bibliography.html.

were particularly influential in Europe, regardless of the fact that they were already out-dated and surpassed in the Islamic world. The preoccupation with these particular works has accounted for the fact that they have been better served by historians: all available materials have been edited and translated into European languages. This activity partly led to the neglect of virtually all of the other Islamic texts on astronomy and mathematics, but a few orientalists and/or historians of science have certainly remedied that situation. Witness, for example, the rediscovery over the past century of the works of al-Bīrūnī, the greatest scientist Islamic civilization ever produced. But al-Khwārizmī, al-Battānī and even al-Bīrūnī, were part of a scientific tradition that knew no rival for many centuries. Thus, when E. S. Kennedy compiled his 1956 survey of Islamic astronomical handbooks with tables, he identified some 125 examples.¹⁶ Benno van Dalen, who has continued the work of Kennedy in spectacular directions, now counts some 250 such works compiled in the Islamic world between 750 and 1900, and his forthcoming publication on Islamic *zīj*es is awaited with anticipation.

I make no apologies to anyone for being an orientalist. What this means to me is that I took great pains to learn some languages, read some medieval manuscripts that nobody else had looked at for centuries, and wrote about what I found. (I admit again that some orientalists with a religious penchant of their own have proposed partisan theories that have been since shown to be untenable: a good example is the literature on the development of the ritual of five prayers in standard Islamic practice, most of which—pushing Jewish, Christian or Zoroastrian connections—has been rendered invalid by further research.) Muslims need to recognize what many unbiased orientalists have achieved over the past few centuries, in order to begin to profit from and to participate in this exciting venture.

Now even the discipline “History of Science” is in some danger. In German it used to be called *Geschichte der Naturwissenschaften*, history of the natural sciences. This is now out of favor, and *Wissenschaftsgeschichte*, meaning, more or less, the history of science in its cultural context, is in vogue. My own university actually appointed a Professor

16. E. S. Kennedy, “A Survey of Islamic Astronomical Tables” in *Transactions of the American Philosophical Society*, N. S., 46:2 (1956): 123-77, repr. with separate pagination, n.d. [ca. 1990].

for *Wissenschaftsgeschichte* recently without even informing or consulting myself, the Professor for *Geschichte der Naturwissenschaften*. (Happily, as a result of the fact that they did not really know what they were doing, they selected a highly-competent historian of mathematics, so all is not lost.) In *Wissenschaftsgeschichte*, there is a great danger that people waffle about science in Islamic civilization without knowing anything about Islamic science, the history of Islamic institutions, or modern research on the history of Islamic science. There are plenty of academics, fortunately none colleagues of mine, who would do this. One danger is that the field attracts scholars who have no background in the texts compiled by the Muslim scholars. One problem is that the history of Islamic institutions has been written by scholars who had little perception of the scientific activity pursued in those institutions. This was not always their fault, because the medieval biographical dictionaries tended to concentrate on scholars with training in the religious sciences. I would like to see somebody work on the long-neglected biographical dictionaries of scientists by Ibn Abī Uṣaybi‘a and Ibn al-Qifṭī; the last person to have looked carefully at these seems to have been Heinrich Suter, when he compiled his monumental 1900 survey of mathematicians and astronomers writing in Arabic. To his credit, he included in his survey numerous scholars known for their teaching activities and intellectual interests, but who did not “publish”. There is serious work to be done in the future, and Dimitri Gutas and Sonja Brentjes, independently, have outlined some of the problems and proposed possible guidelines.¹⁷

As an example of the limitations of old-style *Geschichte der Naturwissenschaften* compared with the potential virtues of new-style *Wissenschaftsgeschichte*, I can cite one close to my heart. I would be the first to admit that some of my earlier writings are inadequate by the

17. Dimitri Gutas, “Certainty, Doubt and Error: Comments on the Epistemological Foundations of Medieval Arabic Science” in *Early Science and Medicine—A Journal for the Study of Science, Technology and Medicine in the Pre-modern Period* 7:3 (2002), pp. 276-89; Sonja Brentjes, “Between Doubts and Certainties: On the Place of the History of Science in Islamic Societies within the Field of the History of the Science” in *NTM – International Journal of History and Ethics of Natural Sciences, Technology and Medicine*, N.S., 11:2 (2003): 65-79.

standards of today. For example, in 1983, I published an essay entitled “The Astronomy of the Mamluks”. I wrote this based on my familiarity with dozens of Mamluk astronomical treatises and a few surviving Mamluk instruments. I did not investigate the information in the available biographical dictionaries on Mamluk scholars (although I since tried to encourage one potential doctoral student, a native-speaker of Arabic, to do just that). So I wrote, for example, that one Ibn al-Majdī in the mid-15th-century had compiled some ingenious auxiliary tables for computing the solar, lunar and planetary positions needed for annual ephemerides (*taqwīm*, pl. *taqāwīm*). I just did not know that Ibn al-Majdī was—in addition to being a professional astronomer at al-Azhar—a legal scholar who taught *fiqh*, a philosopher who taught *ḥikma*, an astrologer who counseled the sultan, as well as a *ṣūfī*, who after becoming head of a *madrasah* converted it to a *khānqāh*. I agree that my essay would have been much richer if I could have included this kind of information. In my own defence, I can claim that at least we have an essay on the technical writings of the astronomers of the Mamluk period, which nobody at the time knew anything about, and on which somebody else can now improve. Also, in my own defence, I can still claim that we seem to have no biographical information whatever on certain Mamluk astronomers beyond the scant references in their astronomical works.

Islam emerged out of a religio-cultural milieu that helped to fashion it. Otherwise, for example, the *Qurʾān* would not originally have been revealed in Arabic with dialectal and foreign lexicographical influence. The Muslim who believes in Islam as the ultimate revelation can take pride in the achievements of Islamic civilization. The orientalist, unless he/she happens to be a Muslim, investigates the history of Islamic civilization with a certain amount of distance. One does not need to be a Muslim to write on the history of any aspect of Islamic civilization, anymore than one need be a Christian to write on the history of any aspect of Christian civilization. (In fact, also solely out of intellectual curiosity, I have recently published on a number-notation used by monks in the European Middle Ages, and on a medieval saint whose history I found to have been completely distorted by virtually all previous writers, so that the entries on her in standard dictionaries of saints are mainly drivel. No Western reader will pose the question: does this author believe in the metaphysical implications of the cosmic triumph of Jesus Christ?)

On Jan 31, 2004, an American convert to Islam, with a Jewish father and Christian mother, was interviewed by CNN about the *hajj*. He mentioned that the Ka'bah, the physical centre of the world of Islam, was in itself nothing more than bricks and mortar. The interested reader will find a lot more about the significance of the layout of the rectangular base of the Ka'bah—based on medieval texts written by Muslims—in the first and fourth of the books mentioned above. When I was teaching at New York University in the early 1980s, I had a doctoral student begin a dissertation—alas never finished—on medieval texts dealing with the Ka'bah. The history of the Ka'bah still has to be written, but it is just one amongst many topics that demands our attention.

The task of the orientalist, or rather, an orientalist with my kind of interests in the practical interaction between Islam and science over many centuries, is to pose questions like the following and seek their answers. Why is the sacred direction in Islam called *qiblah*, from the root *q-b-l*? Why is the term *ṣalāt* for the Islamic prayer ritual written with a *wāw*? Is it significant that the major axis of the rectangular base of the Ka'bah is aligned towards the rising-point of the star Canopus over the horizon of Makkah, and the minor axis is aligned to the solar rising at the summer solstice? Muslims centuries ago certainly thought it was. How have Muslims determined the *qiblah* and the prayer-times over the centuries? Why do medieval mosques face all sorts of curious directions, when any medieval astronomer could have advised on a *qiblah* in accord with contemporaneous geographical knowledge? What is the origin and significance of the distinctive definition of the beginning of the time of the *ʿaṣr* prayer in terms of the *increase* of the gnomon shadow over its midday minimum by an amount equal to the length of the gnomon? Where did this definition, still in use today, but neither in the *Qurʾān* nor in the *ḥadīth*, come from? Why was there in certain Muslim communities in the Middle Ages a sixth prayer at mid-morning called the *ḍuḥā*? Some *aḥādīth* have the Prophet himself performing the *ḍuḥā* prayer, others maintain that he disapproved of it. And why is there no conflict in modern Muslim societies about the times of prayer, but chaos often reigns at the beginning and end of Ramaḍān? These are valid questions on subjects somewhat far from the metaphysical doctrines of Islam, and Muslims can learn a lot about Islam (and about Muslims) from their answers. These answers add to the richness of Islam rather than detract from it.