REVIEW ARTICLE

Jan P. Hogendijk and Abdelhamid I. Sabra, *The Enterprise of Science in Islam: New Perspectives* (Cambridge: The MIT Press, 2003), xxii+386 pp, HB, ISBN 0-262-19482-1

Writing during the formative period of contemporary Western studies of Islamic scientific tradition, Ignaz Goldziher constructed one of the first models of the twentieth century that pitched the so-called sciences of the ancients (*ʿulūm al-awāʾil* or *ʿulūm al-qudamāʾ*)—which included exact sciences—against a nebulous and ill-defined "old Islamic Orthodoxy".[1] This formulation was to influence the whole field in numerous implicit and explicit ways throughout the twentieth century, and it was not until the final decades of the century that his authoritarian position was seriously challenged by a few perceptive scholars who found his characterization of Islamic intellectual tradition highly problematic.

But, in spite of this reassessment, "Goldziherism" continues to reign supreme in numerous studies of Islamic scientific tradition. The central element of Goldziher's theory is that the "ancient sciences", which "included the entire range of propaedeutical, physical, and metaphysical sciences of the Greek encyclopedia, as well as the branches of mathematics, philosophy, natural science, medicine, astronomy, the theory of music and others",[2] were looked upon by the "strict orthodoxy" with mistrust and "with the growing influence of a narrow orthodoxy, this distrust which the religious circles of Eastern Islam felt for the works of the *ʿulūm al-awāʾil* expressed itself with an increasing intensity…the pious Muslim was expected to avoid these sciences with great care because they were considered dangerous to

1. Goldziher, Ignaz, "Stellung der alten islamischen Orthodoxie zu den antiken Wissenschaften," first published as no. 18 (1915) of *Abhandlungen der Königlisch Preussischen Akademie der Wissenschaften* (Philosophische-historische Klasse) (Berlin, 1916), pp. 3-466, translated by M. L. Swartz in his (ed., 1981) *Studies on Islam* (New York/Oxford: Oxford University Press), pp. 185-215; [hereafter Goldziher (1916)].
2. Goldziher (1916), p. 185.

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his faith."[3] According to Goldziher, this opposition made decisive progress after al-Ghazālī (d. 1111) and thus began the decline of Islamic science. This view, which has been cogently called "the marginality thesis" by Abdelhamid I. Sabra, co-editor of the book under review,[4] postulated that

> the scientific and philosophical activity in medieval Islam had no significant impact on the social, economic, educational and religious institutions; that this activity remained itself unaffected by these institutions, except when it was finally crushed by their antagonism or indifference; and that those who kept the Greek legacy alive in Islamic lands constituted a small group of scholars who had little to do with the spiritual life of the majority of Muslims, who made no important contributions to the main currents of Islamic intellectual life, and whose work and interests were marginal to the central concerns of Islamic society.[5]

Repeated, rehashed, and reformulated *ad nauseam*, this view of the scientific enterprise in Islamic civilization became the main working hypothesis for most Western studies of Islamic scientific tradition and, in spite of some well-documented refutations, remains the general framework of inquiry in such diverse disciplines as history of science, sociological studies of scientific enterprise, history of philosophy and various other related fields.[6]

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3. Ibid, pp. 185-6.
4. This apt term was first used by Sabra in his 1987 paper, "The Appropriation and Subsequent Naturalization of Greek Science in Medieval Islam: A Preliminary Statement", *History of Science*, 25, London: Science History Publications Ltd. 1987, pp. 223-43, reprinted in A. I. Sabra, *Optics, Astronomy and Logic: Studies in Arabic Science and Philosophy* (Aldershot: Variorum, 1994); the reprint retains the original pagination.
5. Ibid, p. 229.
6. See, for example, the 1993 book by sociologist Toby E. Huff, *The Rise of Early Modern Science* (Cambridge: Cambridge University Press, 1993) which is permeated with "Goldziherism". Huff is by no means the only contemporary scholar who relies on this approach to "prove" that the Islamic scientific tradition existed and survived not because of Islam but in spite of it. Similar formulations exist in numerous histories of science. As an example, see, David C. Lindberg, *The Beginnings of Western Science* (Chicago: The University of Chicago Press, 1992).

A corollary of this theory is the dating of the so-called decline of science in Islamic civilization. Since al-Ghazālī was held responsible for "killing" science in Islamic civilization, most early historians decided that this demise must have occurred shortly after his death in 1111 AD; more generous histories allow a greater margin and fix the date of this death of science in the thirteenth century. For instance, in his monumental work, *An Introduction to the History of Science,* George Sarton sets the eleventh century as the end of the vigor of the Islamic scientific tradition, with the twelfth century, and to a lesser extent the thirteenth century, as being the centuries of transition of the vigor to Europe.[7]

This view became entrenched in the Western academic world and most histories of science continue to repeat it with dismissive and categorical statements such as: "During the thirteenth and fourteenth centuries, Islamic science went into decline; by the fifteenth century, little was left."[8] After passing their verdict, these historians attempt to answer the obvious question that arises out of this death sentence: "How did this come about?" The answer is provided by a recourse to Goldziherism. A case in point is the influential work by David Lindberg, *The Beginning of Western Science*. On the question of decline, Lindberg first acknowledges that "not enough research has been done to permit us to trace these developments with confidence", and then goes on to identify several "causal factors" for this decline.[9] The first of these is none other than what Goldziher had "identified" in 1916: "conservative religious forces".[10] The second causal factor identified by Lindberg is the "debilitating warfare, economic failure, and the resulting loss of patronage" without which "the sciences were unable to sustain themselves", and the third returns, once again, to a rehashing of Goldziher's hypothesis:

> In assessing this collapse, we must remember that at an advanced level the foreign sciences had never found a stable institutional home in Islam, that they continued to be viewed

7. George Sarton, *Introduction to the History of Science* (Baltimore: Published for the Carnegie Institute of Washington by The Williams & Wilking Company, 1931-48, 3 vols.), vol. 2, part 1, pp. 1-2.
8. Lindberg (1992), p. 180.
9. Ibid.
10. Goldziher (1916), pp. 192-3.

> with suspicion in conservative religious quarters, and that their utility (especially as advanced disciplines) may not have seemed overpowering. Fortunately, before the products of Islamic science could be lost, contact was made with Christendom, and the process of cultural transmission began anew.[11]

This general trend, followed by most historians, then describes the enterprise of science in Islam as a passing phenomenon in the emergence of "real science"; this creates many historiographic problems and entails the danger of unconsciously slipping from the historical fact into the Whiggish view of history—to borrow J. L. Berggren's term—as if the final purpose of the cultivation of science in the Islamic civilization was merely to create modern science. "This approach has had two quite opposite, but equally regrettable, results," says Berggren, one of the contributors to the volume under review, in a previous work:

> The first is a treatment of medieval Islam as a civilization deserving of attention only for its role as a channel through which the great works of the Greeks were carried safely to the eager minds of the European Renaissance. The emphasis falls on the two great periods of translations, that into Arabic in the ninth century and that into Latin in the twelfth and thirteenth centuries, and the developments of the intervening centuries provide little more than a series of anecdotes about one curious result or another that was proved by an occasional great figure.
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> The second result of this Whiggish attitude is a selective and tendentious reading of medieval Arabic texts to show how Islamic science prefigured that of modern times…it would be invidious to cite contemporary examples of either of these approaches—and of little interest to cite earlier examples—and I shall only observe that both of these results, which on the surface seem to place such different values on Islamic civilization, should concur in valuing it only insofar as it served ends not its own; this is hardly surprising, since both are motivated by a fundamental interest not in the past but in the present.[12]

11. Lindberg (1992), pp. 181-2.
12. J. L. Berggren, "Islamic Acquisition of the Foreign Sciences: A Cultural Perspective" in Jamil F. Ragep and Sally P. Ragep, (eds.), *Tradition, Transmission, Transformation* (Leiden: E. J. Brill, Leiden, 1996), pp. 263-83. This paper is a revised version of an

One can cite text after text to show the truth of Berggren's statement. The track etched by Goldziher was so deep that most subsequent works have fallen in his steps.[13] His "Islamic Orthodoxy versus Foreign Sciences" hypothesis, first published in German in 1916, was to remain paradigmatic for almost all subsequent studies until the close of the twentieth century. But, as recent scholarship has clearly established, this hypothesis is untenable for several reasons, not least of which is the very foundation of the work which rests on undefined notions of Islamic "orthodoxy" and "old orthodoxy".[14] With the demolition of this foundation, several associated ideas, such as the "golden age of Islamic science" and the dating of decline of science, started to crumble.[15]

As the painstaking work of a small group of historians of science accumulated more textual sources for a better understanding of the enterprise of science in Islam, the boundaries of decline were pushed further in time and eventually the very ideas related to a definite time period of decline and that of the so-called "golden age" were seriously challenged. Thus the oft-repeated notion of the end of the thirteenth

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article which appeared in *The American Journal of Islamic Social Sciences (AJISS)*, vol. 9 (1992) 3: 310-24.

13. If one were to compile a list of this repetitive literature, it would become abundantly clear that all of this literature is reducible to the attitudes summarized in the foregoing paragraphs. For specific examples, one can see the treatment of the question of decline in such works as Edward Grant, *The Foundations of Modern Science in the Middle Ages* (Cambridge: Cambridge University Press, 1966), especially pp. 176-86; and A. C. Crombie, *The History of Science: From Augustine to Galileo* (Mineola: Dover Publications, 1995).
14. For an insightful critique of Goldziher's hypothesis, see Dimitri Gutas, *Greek Thought, Arabic Culture* (London and New York, Routledge, 1998), pp. 166-75; also see A. I. Sabra, (1994), op. cit.; and J. L. Berggren (1996), op. cit.
15. In fact, there existed not one but many schemes connected with this idea of a "Golden Age" which fell in different periods of Islamic history, depending on the inclinations of the writer. See, for example, classifications in Marshall G. S. Hodgson, *The Venture of Islam* (Chicago: University of Chicago Press, 1974, 3 vols.); Ira M. Lapidus, *A History of Islamic Societies* (Cambridge: Cambridge University Press, 1988); Bernard Lewis (ed.), *Islam and the Arab World* (New York: Knopf, 1976).

century being the beginning of decline of the Islamic science has been shown to contradict historical data. In fact, it has been plausibly argued by many historians of science that the so-called "golden age of Islamic astronomy" lies between the middle of the thirteenth and the middle of the fourteenth centuries, and not in the ninth-tenth centuries as was previously assumed. For instance, in his 1994 work, *A History of Arabic Astronomy: Planetary Theories during the Golden Age of Islam,* George Saliba expressly states that

> the subtitle of the book intentionally designates this period [of so-called decline] as the Golden Age of Islam. This may be disturbing to students of Islamic intellectual history who are used to dismissing the works produced during this period as insignificant. What the evidence presented here now suggests is that if we can find such original work in astronomical planetary theories, and such mathematical sophistication and maturity in the presentations of these results, shouldn't we consider other disciplines as well, and try to find out if such vigorous scientific activity can be substantiated in other fields? In fact, at various points in these articles [of the book] I suggest that such research would promise to be extremely rewarding.[16]

This revision of a well-entrenched view notwithstanding, the general histories of science written in the West continue to pretend that the most original works of the thirteenth and the fourteenth century astronomers and mathematicians—such as Athīr al-Dīn al-Abharī (d. *ca.* 638/1240), Muʾayyad al-Dīn al-ʿUrḍī (d. 665/1266), Naṣīr al-Dīn al-Ṭūsī (d. 673/1274), Quṭb al-Dīn al-Shirāzī (d. 711/1311) and Ibn al-Shāṭir (d. 777/1375)—simply did not exist as part of a well-established scientific tradition. Or as if the work of al-Jazārī (d. *ca*. 602/1205) in mechanics and Ibn al-Nafīs (d. 687/1288) in medicine have no relevance to the general history of science. It is as if these historians draw their material from another planet where they have no access to that extraordinarily lucid inside account of the Islamic astronomical tradition preserved for us in a private letter written by Jamshīd Ghiyāth al-Dīn al-Kāshī (d. 833/1429),[17] the

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16. George Saliba, *A History of Arabic Astronomy* (New York and London: New York University Press, 1994), p. 8.
17. One of the most important among a group of scientists working at the Samarqand Observatory. Two of his works, written towards the end of his stay in Samarqand, deal with the computation of

celebrated author of *Sullam al-Samā*ʾ, to his father, shortly after his arrival in that fabulous city of blue domes where Ulugh Beg (797-853/1394-1449) had gathered "sixty or seventy" astronomers and mathematicians at the madrasah and observatory he had built for scientific research. Both the madrasah and the observatory of Ulugh Beg are still standing in Samarqand, but the astronomers are no more. The impressive tile work and symmetrical architectural features of these buildings remind visitors of the accomplishments of a tradition which *The Enterprise of Science in Islam: New Perspectives* attempts to document. This new volume, with contributions by some of the most important historians of Islamic scientific tradition, indeed stands out in a sea of histories of science written by those who simply ignore the fact that "at the time Ulugh Beg's observatory flourished[,] it was carrying out the most advanced observations and analysis being done anywhere. In the 1420s and 1430s Samarqand was the astronomical and mathematical 'capital of the world'".[18]

It is in this background that *The Enterprise of Science in Islam: New Perspectives* must be seen as a work which significantly adds to our understanding of the enterprise of science in the Islamic civilization. Contributors to this volume include important scholars who have done much to demolish that house of cards built by Goldziher and his followers through devices such as the "marginality thesis" and "science versus old Islamic Orthodoxy theory".

The twelve papers collected in *The Enterprise of Science in Islam: New Perspectives* were first presented at a conference on "New Perspectives in Islamic Science" held at the Dibner Institute for the History of Science and Technology in November 1998. They advance the general level of research on Islamic science, raise new questions, and answer

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2π and the sine of 1°, both fundamental qualities in mathematics, to nine significant sexagesimal fractional digits (equivalent to 16 decimal places). His *Khāqānī Zīj* was a revision of al-Ṭūsī's *Īlkhānī Zīj* and contained geographical and trigonometric tables independent of those found in Ulugh Beg's *Zīj*. On al-Kāshī, see sources cited by David King, *World-Maps for Finding the Direction and Distance to Mecca* (Leiden/London: E. J. Brill and Al-Furqān, 1999), p. 44, n. 92.

18. Kevin Krisciunas, quoted from E. S. Kennedy, "Ulugh Beg" in *Cambridge History of Iran* (Cambridge: Cambridge University Press, 1993), p. 11.

some of the old questions.

The book has been divided into six groups; there are two papers in each group. Group headings provide a quick overview of the main themes of the book: Cross-cultural Transmission; Transformations of Greek Optics; Mathematics: Philosophy and Practice; Numbers, Geometry and Architecture; Seventeenth-century Transmission of Astronomy; Science and Medicine in the Maghrib and al-Andalus. The volume does not aspire to cover the entire spectrum of Islamic mathematical sciences, the editors note, but the twelve chapters are related to each other in diverse ways and the six groups are not water-tight compartments. A useful synoptic overview of the twelve chapters is offered by the editors in their "Introduction":

> Most of the chapters are, in one way or another, related to transmission of scientific knowledge, either from one culture to another (Kunitzsch, Burnett, Kheirandish, Sabra, Endress, Berggren, Pingree), or within the medieval Islamic world itself (Kunitzsch, Samsó, Djebbar). Three chapters discuss mainly astronomy (Burnett, Pingree, Samsó), five chapters are entirely or mainly on mathematics (Kunitzsch, Berggren, Sesiano, Dold, Djebbar), two chapters are on optics (Sabra, Kheirandish), while the chapter by Endress concerns the philosophy of the mathematical sciences. Several chapters are concerned with the relationship between the exact sciences and other fields, such as natural philosophy (Kheirandish, Endress), architecture (Dold), medicine (Langermann). Some chapters concern outsider's views on mathematics and its use (Endress, Langermann), and medieval debates on scientific methodology (Berggren, Sabra). Two chapters discuss the individual mathematicians al-Kūhī (Berggren,) and al-Kāshī (Dold), whose styles and attitudes turn out to be very different. The chapters by Djebbar, Langermann, and Samsó concern geographical areas… (viii)

The articles collected in this volume are not casual papers; they summarize many years of painstaking research in a field which remains understudied partially because of paucity of source material. These papers not only present new insights into the Islamic scientific tradition, they bring to light hitherto unpublished source material in Arabic and other languages. They also broaden our general understanding of the enterprise of science in the Islamic civilization by documenting the view that "the Islamic scientific tradition was even richer, more profound, and with more complex relations to other cultures than had been thought hitherto." (ix)

The subtitle of the volume, "New Perspectives", is not merely an appendage for marketing; the conference for which these papers were first written was especially concerned with this aspect of research and the helpful "Introduction" by the editors identifies and outlines these "new perspectives" for each chapter.

The book opens with Paul Kunitzsch's article, "The Transmission of Hindu-Arabic Numerals Reconsidered". Kunitzsch attempts to distinguish the fairly established issues in this area from those which require further research. Thus, he accepts as established the generally acknowledged view that the nine numerals plus a symbol for an empty place came to the Arabs from India in the eighth century, but rejects Ganz's hypothesis that the dust board utilized by the Muslim mathematicians was the model for the Latin abacus. He argues that the dust numerals (*ḥurūf al-ghubār*) rather refer to the written figures as opposed to the non-written numerals of the process known as mental or finger reckoning. He then emphasizes the need for further research to establish the existence of Hindu-Arabic numerals in the Western-Islamic sources prior to 1300 AD.

"The Transmission of Arabic Astronomy via Antioch and Pisa in the Second Quarter of the Twelfth Century", the second chapter of the book, is written by Charles Burnett, Professor of the History of Islamic Influences in Europe at the Warburg Institute, University of London. He explores a hitherto neglected channel of transmission of the exact sciences from the Islamic scientific tradition to Europe before the emergence of Toledo as a center of the translation movement. His article provides an interesting insight into the textual analysis that can lead to general conclusions about transmission of science from the Islamic civilization to Europe. Through an examination of the technical terminology and systems of numeration of a group of Latin astronomical texts that consist of a translation of Ptolemy's *Almagest*, the "Dresden *Almagest*"; a Latin cosmology describing the Ptolemaic system, the *Liber Mamonis*; and a version of the astronomical tables of al-Ṣūfī, Burnett shows rather convincingly that unlike the majority of Arabic scientific works, these came to Europe directly from Antioch (now in Turkey). This conclusion not only opens up a vast new area of research centered around transmission, it also provides new insights into the methodology of internal textual analysis that can be used to draw such conclusions. Burnett concludes by stating that much more work needs to be done on this subject and that the mechanics of the transmission of the

Toledan translations are still not clear.

Elaheh Kheirandish, currently a senior research fellow at The Dibner Institute for the History of Science and Technology, contributes to the volume with a fascinating account of the transformation of Greek optical terms as early as the ninth-century. Her article, "The Many Aspects of 'Appearances': Arabic Optics to 950 AD", takes a chapter from al-Fārābī's *Iḥṣā᾽ al-ʿulūm* (*Catalogue of the Sciences*), "a work representing the state of many fields up to about the mid-4th/10th century", as its starting point, and constructs a coherent and comparative account of the optical terms used in Arabic and Greek sources. Divided into five sections (Veracity and Accuracy of Vision; Justifiability and Variety of Demonstration; Versatility and Fallibility of Applications; Elements and Mechanisms of Vision; Modes and Mediums of Operations), the article concludes by highlighting the complexity of the early optical tradition.

Abdelhamid Sabra's chapter, "Ibn al-Haytham's Revolutionary Project in Optics: The Achievement and the Obstacle" not only brings to light the results of a life-time study of the works of Ibn al-Haytham, it also claims to use the word "revolution" in its title "in the strict sense of a conscious and radical transformation of a widely practiced and accepted approach to a whole scientific discipline, a transformation that goes to the heart of the basic assumptions of the traditional system." (xii) Sabra, one of the co-editors of the volume, has previously published some of the most important conceptual schemes for understanding the processes of transmission of scientific knowledge to and from Islamic civilization. His chapter is "an outline of the single, continuous argument which…runs through all the seven books that make up the *Optics* of Ibn al-Haytham: Having totally rejected, on the basis of empirical evidence, the visual-ray hypothesis as the foundation of previous mathematical theories of vision, and aligning himself (again on the basis of experience) with the peripatetic view of vision as the reception of forms of light and color, Ibn al-Haytham was led to accord psychology a new, inevitable and fundamental role never realized earlier in the works of the Greek mathematicians and their Arabic successors." (xii)

Gerhard Endress of the University of Bochum, who has published textual editions and studies of the Arabic translations of Aristotle and late Hellenistic Neoplatonism and who is the co-author (with Dimitri Gutas) of *A Greek and Arabic Lexicon: Material for a Dictionary of the*

Medieval Translations from Greek into Arabic (1992) and (with J. A. Aertsen) *Averroes and the Aristotelian Tradition* (1999), presents a survey of "Mathematics and Philosophy in Medieval Islam". Beginning with Plato and Aristotle, he constructs two opposing views of mathematics and astronomy. Plato believed that numbers and mathematics were related to an eternal world of ideas—the essence and source of our changing world. Aristotle, on the other hand, believed that mathematics was abstracted from reality and not directly related to the essence of the real world. Endress then presents the views of early Muslim philosophers, such as al-Kindī (*ca.* 830) and his followers, who considered mathematics as an intermediary between philosophy and natural science. Taking his account to the generation of Ibn Sīnā (d. 1037) and Ibn al-Haytham (d. *ca.* 1040), Endress constructs a synthetic view of how Ibn al-Haytham, who unlike Ibn Sīnā, was an accomplished astronomer, tried to bridge the gap between Aristotelian physics and Ptolemaic astronomy. His survey then turns to Andalusian astronomers and philosophers and ends with the Jewish philosopher Maimonides (d. 1024) and later Muslim philosophers such as ʿAḍud al-Dīn al-Ījī (d. 1355).

J. L. Berggren, who is currently translating and annotating the extant works of Abū Sahl al-Kūhī, presents an insider's view of mathematics in the tenth century. His chapter, "Tenth-Century Mathematics through the Eyes of Abū Sahl al-Kūhī", also raises a basic question: "What, if anything, about al-Kūhī's work reflects its origins in Islamic civilization?" This is, indeed, one of the most important questions for understanding the relationship between Islam the religion and the scientific tradition that emerged in the Islamic civilization. Berggren explains this question in the context of mathematics in the following manner:

> …if al-Kūhī's work had been translated anonymously into Latin and stripped, as such works sometimes were, of the dedications and the occasional 'By Allah', what is there that might cause us to suspect that we were dealing with a translation from Arabic and not from Greek? Such a question could not be asked of any zīj, with its references to the coordinates of Mecca or interest in azimuths. It could not be asked of the geometrical solutions to the problem of finding the direction of Mecca given by Ibn al-Haytham. Neither would one ask it of Ibrāhīm ibn Sinān's work on sundials, nor of Abu'l-Wafā''s work on the geometry of craftsmen. (193)

Berggren's question can be extended to the entire enterprise of science in the Islamic civilization: what was Islamic in this enterprise? Before definite answers start to emerge in this realm, a framework of inquiry is needed and one has to answer a host of ancillary questions: how do we define the relationship between any faith tradition and the general contours of various civilizational activities that emerge in that faith community? What are the approaches one can use to explore this nexus? What is the relationship between the meta-scientific worldview which is inevitably present behind the scientific enterprise of all civilizations and the science proper? These, and a host of other questions related to our understanding of the relationship between Islam and the vast scientific enterprise that flourished in the Islamic civilization, are not the focus of this volume per se, but these papers do provide useful source material for this inquiry.

"Numbers, Geometry, and Architecture", the fourth section of the book, opens with a chapter on the most complex type of magic squares thus far found in the Islamic tradition. Calling these squares "Quadratus Mirabilis" and using it as the title of the chapter, Jacques Sesiano, who teaches history of mathematics at the École Polytechnique Fédérale de Lausanne, shows that the theory of magic squares reached a much higher level in the tenth century than had been previously thought. Combining mathematics and geometry in a science dealing with the "harmonious disposition of numbers" (*aʿdād al-wafq*), Muslim mathematicians had studied in depth what are now called magic squares, that is, a square array of integer numbers in which the sum of all elements in each column, row, or diagonal are equal. Sesiano notes that information about the beginning of interest in magic squares is lacking, but proposes that it may have been connected with the introduction of chess. "We know that treatises on magic squares were written in the ninth century," he says, "but the two earliest extant texts date back to the tenth century; these are: *Treatise on the magic disposition of numbers in squares* by Abʾl-Wafāʾ al-Būzjānī (940-997 or 998) and a chapter in Book III of ʿAlī b. Aḥmad al-Anṭākī's (d. 987) *Commentary on Nicomachos's Arithmetic*" (199-200). He uses both of these texts to construct his brilliant survey.

In her chapter entitled, "Calculating Surface Areas and Volumes in Islamic Architecture", Yvonne Dold-Samplonius—who has previously directed the video "Qubba for al-Kāshī", showing al-Kāshī's geometrical constructions for determining the volumes of domes and arches—lists a number of rough calculations of volumes and surfaces of domes from various practical mathematical works until the thirteenth century, and compares these calculations with the sophisticated approach in the *Key to Arithmetic* of al-Kāshī, who computed various coefficients which enabled craftsmen to easily find surfaces and volumes of various types of domes found in Central Asia. Dold-Samplonius finishes her chapter with a brief examination of al-Kāshī's discussion of one of the distinctively Islamic features of architecture, the stalactite vaults (*muqarnas*), the subject of her current research.

Her otherwise fascinating paper, however, suffers from insufficient exploration of the symbolic importance of architectural forms in Islam in general and mosques in particular. This is further accentuated by the use of a dated source for drawing primary concepts. She uses K. A. C. Creswell's 1958 work, *A Short Account of Early Muslim Architecture*, and his 1960 article "Architecture" in the *Encyclopaedia of Islam* as her primary sources for introducing Islamic Architecture (235-7); both are utterly inadequate for outlining the striking characteristics of mathematical patterns in Islamic architecture which "does not derive from external historical influences, Greek or otherwise. It derives from the Qurʾān whose own mathematical structure is bewildering and reveals an amazing rapport between Islamic intellectual and spiritual concerns and mathematics."[19] These connections can also be gleaned from a building like the Córdoba Mosque, one of the finest expressions of Islamic architecture, where the innate harmony that emanates from the form of the Islamic structure is obvious. In a mosque, "wherever a worshipper happens to be standing or kneeling on a mat, for him that spot is the center of the mosque, indeed of the world".[20] Dold-Samplonius could have profited from standing by the prayer niche and the marvelous array of columns and arches of the Córdoba Mosque, which have a hypnotic symmetry, as well as from an exploratory look at the pillars "linked by horseshoe-shaped arches immediately above the abaci… [where] the arches appear to be suspended like so many rainbows in the sky… [and] the whole

19. Seyyed Hossein Nasr, *Islamic Art and Spirituality* (Albany: State University Press of New York, 1987), p. 47.
20. Titus Burckhardt, *Moorish Culture in Spain,* trans. by Alisa Jaffa and William Stoddart (Louisville: Fons Vitae, 1999), p. 11.

structure seems to expand and extend outwards as the eye travels upward; the fan-shaped alternation of light and dark voussoirs intensifies this impression—the impression of a room that appears to fan outwards from many centers, and is at once motionless and mobile".[21]

What is missing from her chapter becomes even more pronounced because of its importance in understanding various aspects of practical mathematics in Islamic civilization—the subject of her paper—which were used to blend many features of various sciences, arts, and architectural motifs for a peculiar Islamic usage of colors, light, and forms. Mathematical theories were not only used to create a unique space inside the niche of the mosques—which evoke the feeling of awe and remind one of the mysterious "niche of light" passage in the celebrated "Light Verse" of the Qurʾān (24:35)—but which were also used to construct the fluted shell-like vault, designed to produce extraordinary acoustics for the transmission of the recitation of the Qurʾān to the far corners of the mosque, and the horseshoe shaped arches that seem to breathe "as if expanding with a surfeit of inner beatitude, while the rectangular frame enclosing it acts as a counterbalance. The radiating energy and the perfect stillness from an unsurpassable equilibrium."[22]

David Pingree, whose life-long commitment to the history of astronomy, astrology, and astral magic in ancient Mesopotamia, Greece, the Roman Empire, India, the Muslim world, Byzantium, and medieval Europe has given us numerous new insights into the transmission of these sciences between various cultures, contributes to the volume with an article on the transmission of Islamic science to India. "The Sarvasiddhāntarāja of Nityānanda" deals with revision of the *Zīj* of Ulugh Beg at the court of the Moghul emperor Shah Jahān at Delhi in the early seventeenth century. This revision was translated into Sanskrit by Nityānanada, but because the Hindu astronomers were not familiar with the Islamic tradition, this work was not well received. Nityānanada then decided to write a Sanskrit apology for Islamic astronomy called Sarvasiddhāntarāja; Pingree presents a detailed analysis of chapters 2 and 3 of this work which deals with the computation of the mean and true longitudes of the planets. This

21. Ibid.
22. Ibid.

chapter sheds light on many neglected aspects of transmission of Islamic astronomy to India and the influence of this transmission.

"On the Lunar Tables in Sanjaq Dār's *Zīj al-Sharīf*", the tenth chapter of the book by Julio Samsó, professor of Arabic and Islamic Studies at the University of Barcelona, draws our attention to the complex issues related to the transmission of scientific knowledge between the eastern and western realms of the Muslim world. The Andalusian astronomical tradition of the ninth through the eleventh centuries had numerous unique features, one of these being the existence of special theories to explain the oscillation in the ecliptic longitudes of all fixed stars with respect to the vernal point. This phenomenon, called "trepidation", was widely studied in the Maghrib, but astronomers of the eastern Islamic astronomical tradition such as Muḥyī al-Dīn al-Maghribī and Ibn al-Shāṭir rejected trepidation; their theories were transmitted to the Maghrib during the late 14th century and, though the astrologers in the Maghrib continued to use the older Andalusian astronomy, more sophisticated Eastern astronomical tradition found favor with the astronomers and *muwaqqits*—the official time keepers in the mosques. Samsó explores the influence of the *Ẓīj* of Ulugh Beg, which was transmitted to the Maghrib in the 17th century, on *Ẓīj al-Sharīf* ("Noble Astronomical Handbook") by Sanjaq Dār of Tunis.

Ahmed Djebbar's article, "A Panorama of Research on the History of Mathematics in al-Andalus and the Maghrib between the Ninth and Sixteenth Centuries" is one of the most important surveys of research on the history of medieval mathematics and astronomy. It covers the period between 1834 and 1980. Djebbar, who is professor of History of Mathematics at Lille University, has previously published *Une histoire de la science arabe* (2001) and *La vie et l'œuvre d'Ibn al-Bannā: un essai biobibliographique* (2001), and he covers both the Arabic sources and the Western literature in his survey. The importance of this survey lies in its synthetic descriptions and in its clear expositions on what needs to be further studied in this area.

The last chapter of the book is by Tzvi Langermann who teaches Arabic at Bar Ilan University. Langermann's title, which deliberately seeks to establish connections with an earlier work by A. I. Sabra,[23] has

23. A. I. Sabra, "The Andalusian Revolt against Ptolemaic Astronomy: Averroes and al-Biṭrūjī" in E. Mendelsohn (ed.), *Transformation*

a meaningful question mark: "Another Andalusian Revolt? Ibn Rushd's Critique of al-Kindī's Pharmacological Computus". The question mark in the title is indicative of the open-ended attitude of the author toward a significant question which some historians have raised and which he briefly mentions: can certain Andalusian trends in science, medicine, philosophy, Islamic Law, and Arabic grammar be interpreted as manifestations of a general revisionist attitude toward the established authorities in those fields in the Eastern part of the Muslim world? Langermann refrains from committing himself to any conclusive response, but his article provides many new insights to Ibn Rushd's vehement attack on al-Kindī's proposal of a non-Galenic computus for calculating the right quantities of simple drugs in order to produce the desired degree of their compounded elemental qualities: heat, cold, dry, and moist. But the importance of Langermann's article is enhanced by the fact that its wider context deals with the general intellectual trends in the Islamic West and their relationship with the Eastern tradition.

All chapters have their own bibliographies, and a comprehensive index is included at the end of the book. This volume deserves full attention of the scholars in the field, but it is general enough for an average reader interested in the Islamic scientific tradition. If one can imagine a comprehensive history of the enterprise of science in the Islamic civilization—which is still decades away—as a project like the construction of a vast palace, this book provides several useful windows, looking into one of its numerous gardens; one only wishes there were more such works to expedite this monumental task, which will also add significantly to our understanding of Islamic civilization as a whole.

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and Tradition in the Sciences (Cambridge: Cambridge University Press, 1984), pp. 133-53; rprnt. A. I. Sabra (1994), op. cit.