THE FATE OF ISLAMIC SCIENCE BETWEEN THE ELEVENTH AND SIXTEENTH-CENTURIES: A CRITICAL STUDY OF SCHOLARSHIP FROM IBN KHALDUN TO THE PRESENT

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ABSTRACT

The aim of this thesis is to comprehensively survey and evaluate scholarship, from Ibn Khaldun (1332-1406) to the present, on the fate of Islamic science between the eleventh and sixteenth-centuries, and to outline a more adequate scholarly approach. The thesis also assesses the logic and empirical accuracy of the accepted decline theory, and other alternative views, regarding the fate of Islamic science, and investigates the procedural and social physiological factors that give rise to inadequacies in the scholarship under question. It also attempts to construct an intellectual model for the fate of Islamic science, one that examines the cultural environment, and the interactions among different cultural dynamics at work. Drawing upon Ibn Khaldun's theory and recent substantial evidence from the history of Islamic science, this thesis also entails justifying the claim that, contrary to common assumptions, different fates awaited Islamic science, in different areas, and at different times.

For the period of Ibn Khaldun to the present, this thesis presents the first comprehensive review of both classical and contemporary scholarship, exclusively or partially, devoted to the fate of Islamic science for the period under study. Based on this review, the thesis demonstrates that, although the idea that Islamic science declined after the eleventh century has gained a wide currency, and may have been established as the preferred scholarly paradigm, there is no agreement amongst scholars regarding what actually happened. In fact, the lexicon of scholarship that describes the fate of Islamic science includes such terms as: "decline," "decadence," "stagnation," "fragmentation," "standstill," and

that Islamic science "froze," to name just a few. More importantly, the study shows that six centuries ago, the Muslim historian Ibn Khaldun provided a more sophisticated and complex theory regarding what happened to Islamic science, which was not utilised except in the work of two scholars. The thesis tests the adequacy of the different claims by applying them to four case studies from the history of Islamic science, and demonstrate that evidence for specified areas shows that different fates awaited Islamic science in different areas and times.

In view of the fact that Ibn Khaldun's theory is six centuries old, and that evidence of original scientific activity beyond the eleventh century emerged in the 1950s, what would one expect the state of scholarship to be? One would expect that with the availability of such evidence the usage of "decline" and other single-faceted terms would begin to disappear from the lexicon of scholarship; scholars would show awareness, and criticism, of each other's work; and development of more and more sophisticated concepts would emerge that would explain the fate of Islamic science. The thesis demonstrates that this did not happen. It argues that the key problem is that, after Ibn Khaldun, there was a centuries-long gap, in which even excellent historians used simple, dismissive terms and concepts defined by a limited, but highly persistent, bundle of interpretative views with a dominant theme of decline. These persistent themes within the scholarship by which Islamic science is constructed and represented were deeply embedded in many scholarly works. In addition, many scholars failed to build on the work of others; they ignored major pieces of evidence; and, in most cases, they were not trying to discern what happened to Islamic science but were referring to the subject as part of another project.

Thus, in this corpus of scholarship, one that contains the work of some of the 'best' scholars, the myth of the decline remains not only intact but also powerful. Convinced of its merit, scholars passed it on and vouched for it, failing to distinguish facts from decisions based on consensus, emotion, or tradition. There are very few noteworthy cases where Islamic science is being represented in ways that do not imply negativity. There are also some few narratives that present more complex descriptions; however, even Ibn Khaldun's complex theory, which is arguably the most adequate in the scholarship, is non-comprehensive. Some modern scholars, like Saliba and Sabra, present a challenge to the common argument that Islamic science suffered a uniform decline. However, in the absence of any significant challenges to the common claims of the fate of Islamic science, particularly that of decline, it is evident that, at the very least, the scholarship seems to offer support to the work of discourses that construct the fate of Islamic science in single-faceted, simplistic and reductive terms.

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"He who does not thank people does not thank Allah."
Prophet Muhammad

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STATEMENT OF ORIGINALITY

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

Mohamad Abdalla

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INTRODUCTION

The history of science is studied for many different reasons. For George Sarton, founder of history of science in America,[1] the study of the history of science is significant because:

> The past cannot be separated from the present without grievous loss. The present without the past is insipid and meaningless; the past without the present is obscure. The life of science, like the life of art, is eternal, and we must view it from the point of view of eternity.[2]

For J. D. Bernal, author of the monumental *Science in History*, the history of science allows one to "analyse the relationship between science and society throughout history."[3] For Joseph Needham, the history of science is important because it breaks through the "parochial, Europe-centred views" of most Orientalists' literature,[4] by disclosing the achievements of traditional civilisations,

[1] Lewis Pyenson, "The History of Science," *American Scientist*, 91,3, 2003, p. 265.
[2]Quoted by Eugene Garfield. "How an Understanding of Science History Is Useful, Enriching, and Rewarding." *The Scientist*, 7, 24, 1993, p.12.
[3] The MIT Press, *Science in History*. 2003. Available: http://www-mitpress.mit.edu/catalog/item/default.asp?sid=C194F6D6-2B09-4514-ACE1-498CFB912E76&ttype=2&tid=7102. (24 June 2003.)
[4] This is literature that treats the "Orient" and "Orientals" as an object of study inscribed by otherness. This typology is based on a real specificity but detached from history, and thus conceived as intangible and essential. This ensures that European man, from Greek antiquity onwards, becomes the measure of all men everywhere. See Chapter two for more details.

and the important contributions they made to what eventually would become the scientific revolution.[5]

By studying the history of science in China, Needham sought to explain whether science was "purely a product of the genius of Europe, or did all civilizations bring their contributions to the common pool."[6] Needham thought that if he could show the priority of the Far East over Europe in innovation, then he could explain the fate that had befallen Chinese and other non-Western civilizations.[7] By examining "Chinese accomplishments *per se* rather than Chinese failure *vis-a-vis* the West,"[8] Needham was able to show that "environmental, social, and political bases" were instrumental for the "Scientific Revolution developing in the West and not in China."[9] With the contributions of Needham on the development of science and technology in China, "the myth that science and technology are essentially European has been exploded."[10]

The history of science is significant for other historians and scholars because it allows them to demonstrate, for example, that scientific developments in sixteenth-and-seventeenth-century India "compare favourably with the contemporary developments in Europe."[11] And that the "failure"[12] of non-Western

[5] Erik Zürcher, "In Memoriam: Dr Joseph Needham, 1900-1995," *The International Institute for Asian Studies* 1995. Available: http://www.iias.nl/iiasn/iiasn5/eastasia/needham.html. (21 June 2003.)
[6] Joseph Needham, "The Historian of Science as Ecumenical Man: A Meditation in the Shingon Temple of Kongosammai-in on Koyasan," in Nakayama and Sivin (eds), *Chinese Science: Explorations of an Ancient Tradition* (Cambridge: MIT Press, 1973), p. 18.
[7] *Ibid.*
[8] *Ibid.*
[9] *Ibid.*
[10] A. Rahman, "Sixteenth – And Seventeenth – Centuries science in India and some problems of comparative studies," in Mikulas Teich and Robert Young (eds), *Changing Perspectives in the History of Science: Essays in honour of Joseph Needham* (London: Heinemann Educational, 1973), p.52.
[11] *Ibid.,* p.53.

science to become a "self-sustaining process"[13] is not the result of the absence of "significant contributions to knowledge and technological achievements,"[14] but the result of the inability to "develop the necessary potential for the growth of knowledge and an organizational framework to allow for the cumulative growth of science and technology."[15]

The history of science of another important civilisation, the Islamic civilisation, has also been the focus of much research in the last few decades. Recent studies in the history of science in the Islamic civilisation have made significant interpretational changes toward Islam's contribution to the grand narrative of the history of science. Increasingly, contemporary scholarship on the history of "Islamic science" (defined later in this chapter) demonstrates that a substantial amount of genuine science was done in Islam. This predated similar discoveries in the West, and it also impacted upon the Renaissance. For example, in the late 1950s, E. S. Kennedy and his students at the American University of Beirut discovered an important work of a fourteenth century Muslim astronomer by the name of Ibn al-Shatir (d.1375). This discovery showed that Ibn al-Shatir's astronomical inventions were the same type of mechanism used by Copernicus a few centuries later,[16] and may have played a key role in the Copernican revolution.[17] Consequently, an unprecedented acceleration of research in Islamic science started from the 1950s onwards. More recently, historian of Islamic science George Saliba was able to show that one of Copernicus's Muslim

[12] *Ibid.*
[13] *Ibid.*
[14] *Ibid.*
[15] *Ibid.*
[16] Owen Gingerich, "Islamic astronomy," *Scientific American*, 254, 10, 1986, p.74.
[17] George Saliba, "Greek Astronomy and the Medieval Arabic Tradition," *American Scientist*, 90, 2002, p.360.

contemporaries, Khafri, was a "brilliant astronomer, whose ability to work with the mathematics of his time is unsurpassed, including that of Copernicus,"[18] and that he could use mathematics much more fluently, and much more competently, than Copernicus could.[19]

According to Emeritus professor of the history of Islamic science, Abdelhamid Sabra, recent studies in the history of Islamic science illustrate that Islam's contribution to science "was even richer and more profound than we had previously thought."[20] Islamic science was important for the "rise of the Renaissance of the twelfth century in Europe,"[21] and it "played an important part in the development of the exact sciences during the Renaissance of the sixteenth century."[22] In fact, Jan P. Hogendijk and Abdelhamid Sabra argue, "the Islamic tradition in the exact sciences continued well into the nineteenth century, and abundant source material is available in the form of unpublished manuscripts in Arabic, Persian, and other languages in libraries all over the world."[23] But, "because important sources have not been identified and studied," there exists no "reliable survey of the entire field."[24] Still newer discoveries may lie over the horizon. No one who reads or writes about Islamic science can avoid the important question: what happened to that scientific enterprise?

In their attempt to provide answers to this question, historians and scholars periodised the fate of Islamic science into a golden age and a decline age.

[18] *Ibid.*
[19] *Ibid.*
[20] Jan P. Hogendijk and Abdelhamid Sabra (eds), *The Enterprise of Science in Islam: New Perspectives* (Cambridge: The MIT Press, 2003), p.vii.
[21] *Ibid.*
[22] *Ibid.*
[23] *Ibid.*
[24] *Ibid.*

Professor of the History of Arabic science, George Saliba, explains that the history of Islamic science is usually periodised into a golden age and a decline age.[25] This periodisation goes as follows: Before Islam, there was no science worth mentioning.[26] This was followed by a period of translation (the eighth and ninth centuries) during which the Arabs acquired the ancient sciences.[27] Then came a period of original thinking and contribution, known as the golden age, which is said to have lasted from the end of the ninth century to the end of the eleventh century.[28] This was then followed by the age of decline in all intellectual Arabic thought.[29] Hence, as far as the fate of science in Islam is concerned, Sabra explains:

> The question frequently takes the form of why it declined in Islamic lands after the initial flowering. But sometimes it is formulated as the question of why the seventeenth century breakthrough had escaped the Islamic scientists who had based their endeavours on the same foundations that later served their European successors.[30]

These are important questions, given the fact that Islam led the world in science for a long period. Sabra elaborates on the importance of these questions saying:

> There are those who consider the question meaningless, especially in its

[25] George Saliba, *The Origin and Development of Arabic Scientific Thought*, [Arabic] (Balamand University, 1998), p.164.
[26] *Ibid.* This, and the following comments made by Saliba, is my own translation from the original Arabic work.
[27] *Ibid.*
[28] *Ibid.*
[29] *Ibid.* One of the aims of this thesis is to show the extent to which such a periodisation does violence to historical reality.
[30] A. I. Sabra. "The appropriation…" *op.cit.*, p.238.

> latter form, and accordingly refuse to speculate about it. Others would go so far as to maintain that the historian of Islamic science cannot address a more important question. It has become clear in any case that this is one of those questions that need to be subjected to critical analysis before one sets about finding an answer. That the question cannot be easily dismissed is shown in the not insignificant literature devoted to it, and even more in the fact that it almost always crops up in general discussion.[31]

The literature review in Chapter Four shows that most scholars accept, and vouch for, the theory that Islamic science declined after the eleventh century. Since the decline of Islamic science is almost always taken for granted, and the question that scholars generally pose is why Islamic science declined, the initial aim of this thesis was to survey the factors that led to this decline and assess their accuracy. To investigate these factors, it is logical to begin by surveying scholarly work that has already been carried out in the field.

An extensive critical review of both classical and contemporary scholarship, exclusively or partially, devoted to the general question of the fate of Islamic science between the eleventh and sixteenth-centuries revealed some interesting findings.[32] Although the idea that Islamic science declined after the eleventh century has gained a wide currency, and may have been established as the preferred scholarly paradigm, the review of literature shows that there is no agreement amongst scholars regarding what happened to Islamic science after the

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[31] *Ibid.*
[32] The study does not review studies on specific topics, but those that make general statements about the fate of Islamic science. Obviously, the author does not know every little study of every little document and artefact.

eleventh century, or why. The lexicon of scholarship that describes the fate of Islamic science includes such terms as: "decline," "decadence," "stagnation," "fragmentation," "standstill," and that Islamic science "froze," to name just a few. Moreover, the fate of Islamic science is often represented in strongly negative and single-faceted terms, thus implying a lack of originality, and the effect it had on the grand narrative of the history of science. In addition, the review shows that, six centuries ago, the Muslim historian Ibn Khaldun (1332-1406) provided a sophisticated and complex theory regarding what happened to Islamic science, which was not utilised except in the work of two scholars.

One of the assumptions underlying adequate scholarship is that a systematic effort allows faulty theories based on mistaken assumptions, or unsustained predictions, to be either "repaired" or "abandoned."[33] In historical study, a basic requirement is the checking of original sources in order "to review the primary evidence and the judgments drawn at the earliest steps in a sequence."[34] Therefore, in view of the fact that Ibn Khaldun's theory is six centuries old, and that evidence of original scientific activity beyond the eleventh century emerged in the 1950s, what would one expect the state of scholarship to be? One would expect that with the availability of such evidence the usage of "decline" and other single-faceted terms would begin to disappear from the lexicon of scholarship; scholars would show awareness, and criticism, of each other's work; and development of more and more sophisticated concepts would emerge that would explain the fate of Islamic science. This did not happen!

[33] Richard F. Hamilton, *The social misconstruction of reality: Validity and verification in the scholarly community* (New Haven: Yale University Press, c1996), p.xii.
[34] *Ibid.,* p.8.

The key problem is that, after Ibn Khaldun, there was a centuries-long gap, in which even excellent historians used simple, dismissive terms and concepts defined by a limited, but highly persistent, bundle of interpretative views with a dominant theme of decline. These persistent themes within the scholarship by which Islamic science is constructed and represented were deeply embedded in many scholarly works. In addition, many scholars failed to build on the work of others; they ignored major pieces of evidence; and, in most cases, they were not trying to discern what happened to Islamic science but were referring to the subject as part of another project. Therefore, perforce, the focus of this dissertation was changed: instead of continuing the analysis of why Islamic science declined, the research focused upon *why* adequate scholarship does not exist to date that could explain what happened to Islamic science. Since the scientific tradition in Islam lasted for a long period beginning from A.D. 800, this thesis shall concentrate on the period between the eleventh and sixteenth-centuries. This period is chosen for two reasons. First, most writers accept that the eleventh century marked the peak of Islamic science. Second, according to Saliba, there is not enough modern research that covers scientific achievements of the sixteenth century,[35] let alone the period beyond it.

Based upon insights drawn from the theoretical and practical parts of the study, the thesis demonstrates that, as a whole, the scholarship has failed to understand what happened to Islamic science between the eleventh and sixteenth-centuries. It shows that most of scholarship's contribution to the understanding of the fate of Islamic science is through representations that invoke dominant and single-faceted

[35] Saliba, *The Origin and Development of Arabic Scientific Thought*, *op.cit.*, p.187.

claims, in ways that work to reinforce their acceptance as commonsensical truths. These claims work to construct a simplified model of the fate of Islamic science, and thus describe all branches of Islamic science in terms of failure. In doing so, they impose tight scholarly constraints on the possibilities of other alternatives.

Thus, in the corpus of scholarship that contains the work of some of the 'best' scholars, the myth of the decline remains not only intact but also powerful. Convinced of its merit, scholars passed it on and vouched for it, failing to distinguish facts from decisions based on consensus, emotion, or tradition. There are very few noteworthy cases where Islamic science is being represented in ways that do not imply negativity. There are also some few narratives that present more complex descriptions; however, even Ibn Khaldun's complex theory, which is arguably the most adequate in the scholarship, is non-comprehensive. Some modern scholars, like Saliba, present a challenge to the common argument that Islamic science declined. However, in the absence of any significant challenges to the common claims of the fate of Islamic science, particularly that of decline, it is evident that, at the very least, the scholarship seems to offer support to the work of discourses that construct the fate of Islamic science in single-faceted, simplistic and reductive terms.

The aim of this thesis, therefore, is to comprehensively survey and evaluate scholarship on the fate of Islamic science between the eleventh and sixteenth-centuries, and to outline a more adequate scholarly approach. The thesis also attempts to assess the logic and empirical accuracy of the accepted decline theory and other alternative views regarding the fate of science in Islam, and investigates the procedural and social physiological factors that give rise to inadequacies in the scholarship under question. It also attempts to construct an intellectual model for the fate of Islamic science, one that examines the cultural environment, and the interactions among different cultural dynamics at work. Drawing upon Ibn Khaldun's theory and recent substantial evidence from the history of Islamic science, this thesis also entails justifying the claim that, contrary to common assumptions, different fates awaited Islamic science, in different areas, and at different times.

A number of methodological approaches (positivist, relativist, Marxist, or post-modernist) can be used to evaluate the scholarship under study. These approaches (explained in Chapter Three) might well have valuable insights to offer, but do not yield a community that can investigate what happened to Islamic science. However, a normative approach will be used in this study. The conception that will be adopted in this thesis is widely recognised, and yields some fairly straightforward criteria, which makes it possible to examine whether a functioning community exists that could investigate what happened to Islamic science. The key point is that the approach used here is a normative one: what should be the case rather than what actually is. What factors would facilitate (or hinder) the production of reliable knowledge in a scholarly community? The thesis begins with background information on the importance of Islamic science, and examines what an ideal scholarly community would require for the production of reliable knowledge. It then reviews related literature and also presents four cases from the history of Islamic science. The thesis then offers a discussion of factors likely to contribute to inadequacies in the scholarship, and a possible intellectual model for the fate of Islamic science.

SIGNIFICANCE OF THE THESIS

The importance of this thesis lies in the fact that, for the first time, it exposes the inadequacy of the scholarly community in understanding one of the most challenging questions of the history of science. It provides explanations for this inadequacy. And it indicates what a more adequate theory of the fate of Islamic science would look like, that is, a framework for scholars to work within, which will be less misleading.

This study is significant from a number of other perspectives. At a general level, it is significant for its focus on a body of scholarly writings which, belonging to some of the most renowned scholars, have high reputation and have the potential to influence a wide audience of both general public and specialist scholars. As the review of literature in Chapter Four reveals, apart from some long-held theories and views about the fate of Islamic science, there has been little serious and comprehensive analysis of what actually happened to Islamic science between the eleventh and sixteenth-centuries. The study also makes a useful contribution to ongoing debates in the field of the history of Islamic science, particularly about its fate, and the causal factors involved. Since no clear account is given of what happened to Islamic science, it is impossible to discuss the reasons for its fate. This study encourages scholars and students alike to look beyond the conventional causal factors that are offered for the fate of Islamic science.

At a more practical level, the study's significance and originality lie in addressing a gap in current research on the history of Islamic science. In Chapter Four it becomes evident that scholarship has essentially failed in understanding what happened to Islamic science, and that after Ibn Khaldun there was a centuries-long gap, in which even excellent historians simply used simplistic and dismissive terms regarding what happened. Furthermore, examination of the evidence for specific areas shows that different fates awaited Islamic science in different areas at different times. Certainly, the study shows that there is no evidence of a general decline, and it is clear that Islamic science flourished for centuries after the eleventh century.

Originality also lies in the method for arriving at the above conclusion. The conclusion is arrived at by presenting - for the first time - a comprehensive review of scholarship in order to analyse the various insights about the fate of Islamic science that are constructed within them. By analysing the understanding of this fate that is embedded in such texts, the study seeks to document the ways in which these texts may work to reinforce, or to challenge, conventional understanding of what happened to Islamic science. It also shows that erroneous notions proved resilient, despite ongoing research that challenges the long-established assumptions that Islamic science suffered a general decline.

Its originality and significance also lies on the one hand, in the unique intellectual framework (model) that is constructed in Chapter Ten of the thesis. Composed of conceptual examinations of the nature of the Islamic empire, the distance it covered, the geographical and societal variations it underwent, this framework provides a more or less consistent account of how the fate of Islamic science should be viewed and examined. The importance and originality of this account lies, on the other hand, in how this framework allows us to participate in this discussion between the leading scholars in the field of debate, and to make an informed contribution to it by suggesting to the ways in which certain problems are to be overcome.

In short, the original contribution of this thesis lies in the complex process of review, construction and application which is utilised in order to develop a theoretically sophisticated framework, one that can be applied to some of the most urgent and far-reaching practical issues in contemporary history of science, such as the fate of Islamic science and the role different factors played in shaping it.

DEFINITION OF KEY TERMS

Due to inherent ambiguity, it will be useful to clarify two key terms, which are at the heart of the thesis. The terms are: (1) Islamic science, and (2) the decline theory. There is almost a consensus about the meaning of "decline" amongst scholars, even though there is disagreement about the actual period of decline and its causes. There is no agreement on a definition for "Islamic science," therefore an attempt is made to clarify the sense in which the term is being utilised. However, it is not clear that it is possible to dispose of the inherent ambiguity of the terms in what follows. This is partly because individual theorists offer definitions of their own.

(1) ISLAMIC SCIENCE

According to Saliba, the more "historians of science deconstruct the grand narrative of the history of their discipline," the harder it becomes to "assign linguistic, civilisational and cultural adjectives to 'science.'"[36] Using "adjectives such as Greek, Arabic, Chinese, Indian, and more pertinently western, when applied to science as in Greek science, Arabic science, etc., are quickly becoming obsolete,"[37] because of "the newly-emerging understanding of the essentially hegemonic meanings such adjectives have always harboured."[38] These terms were often used as analytical categories that "imparted some significance at the time when languages, cultures and civilizations used to embody individual characteristics that could distinguish them from one another."[39]

Such terms are no longer "serving the same functions," because the "new scrutiny now being applied to such grand narratives of the history of science is making it quite obvious that these terms can no longer yield the same analytical results they used to yield."[40] In addition, such terms as culture, civilization, language, and science "are no longer the same stable, commonly-accepted terms of reference they once were."[41] This is because they "embody ambiguities of their own and embody hegemonic theoretical structures that prohibit their modification with the old adjectives as was once done."[42] Furthermore, the intimate interconnectedness between scientific traditions makes it almost "meaningless to speak of a Greek,

[36] George Saliba, "Whose Science is Arabic Science in Renaissance Europe," *Columbia University* http://www.columbia.edu/~gas1/project/visions/case1/sci.1.html. (21.May.2003).
[37] *Ibid.*
[38] *Ibid.*
[39] *Ibid.*
[40] *Ibid.*
[41] *Ibid.*
[42] *Ibid.*

Arabic or European science as if each had a character of its own."[43]

In this thesis, Islamic science[44] will not imply the religious Islamic sciences (e.g., Jurisprudence), or the type of science that is based on the idea that all knowledge, including scientific knowledge, can be found in the Qur'an.[45] The latter view examines the scientific content of the Qur'an that claims, "From relativity, quantum mechanics, big bang theory to the entire field of embryology and much of modern geology has been 'discovered' in the Qur'an."[46] Its adherents claim that scientific experiments have been devised to discover what is mentioned in the Qur'an but not known to science.[47] Although this view is now the most popular version of Islamic science, it is not the one implied in this thesis.

Islamic science, as used here, does not imply the mystical perspective that equates Islamic science with the study of the nature of things in an ontological sense.[48] In this viewpoint, "the material universe is studied as an integral and subordinate part of the higher levels of existence, consciousness and modes of knowing."[49] Given such a context, science is not "a problem solving enterprise and socially objective inquiry but more as a mystical quest for understanding the Absolute."[50] This view also advocates the idea that "in this universe, conjecture and hypothesis have no real place; all inquiry must be subordinate to the mystical experience."[51]

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43 George Saliba, "Greek Astronomy and the Medieval Arabic Tradition," *American Scientist*, 90, July-August 2002, p.367.
44 Sometimes it is also called "Arabic Science."
45 Ziauddin Sardar, "Islamic Science," www.islamonline.net/english/Contemporary/2002/05/Article21.shtml. (2/6/2002).
46 *Ibid.*
47 *Ibid.*
48 *Ibid.*
49 *Ibid.*
50 *Ibid.*
51 *Ibid.*

Thus, its advocates view all science in Islamic civilization as sacred science, a product of a particular mystical tradition that traces its roots to the Greek neo-Platonists.[52]

In light of the above, Islamic science simply means science[53] conducted mainly in Arabic and within the context of Islamic civilisation, for many individuals from different ethnic and religious backgrounds were actively engaged in this undertaking: Christians (like Hunayn bin Ishaq), Persians (like Ibn Nawbakht), Sabians (like Thabit bin Qurrah), and Jews (like Masha'allah). Arabic was the main scientific language used, but not necessarily the native language of these scientists, who might have been Persian, Turkish or of other origins. While the terms Islamic science and Arabic science are modern historical terms within the context of Islamic civilisation, this science is Islamic in the sense that it suited the new and growing needs of the Islamic civilisation; was available entirely in Arabic, which had replaced Syriac; and was familiar to an increasing number of Muslim translators, students and scientists.[54] It is in this context that the term Islamic science will be used in this thesis.

(2) THE DECLINE THEORY

[52] *Ibid.*
[53] By science we mean, "systemized knowledge derived from observation, study, and experimentation carried on in order to determine the nature or principle of what is being studied." This definition specifically excludes such applied fields as technology and engineering. Ahmad al-Hassan and Donald Hill's book *Islamic Technology* (Cambridge University Press, 1986) addresses Islam's contribution to technology.
[54] G. M. Wickens, "The Middle East as World Centre of Science and Medicine," in Savory, R. M. (ed.), *Introduction to Islamic Civilisation* (Cambridge: Cambridge University Press, 1976), p.113.

The decline theory involves the view that Islamic science went through a golden age in the eleventh century, and then entered a period of more or less uniform decline. The decline theorists would accept the existence of some science after the eleventh century, but would postulate that it was always inferior in both quantity and quality to what had gone before. Several consequences appear to follow from this view. First, since the decline was largely uniform, it follows that some common factor must be responsible for such a decline. Since for long periods of time the only factor that different regions of Islam had in common was religion, the decline theorists will naturally look to characteristics of Islam to explain the decline. Of course, if a substantial amount of original scientific practices were found to have been conducted after the eleventh century, the theory would be proven false. In addition, if science in different parts of the Islamic world were shown to have experienced different fates, the decline theory would be seriously undermined. One of the contentions of this thesis is that both these circumstances have now come to pass.

STRUCTURE OF THE THESIS

Chapter Two shows that a huge and brilliant entity, the Islamic Empire, did a great deal of science in the sense defined above. The chapter highlights some of the ways in which classical and contemporary scholars have understood the importance of Islamic science in the grand narrative of the history of science, and how this understanding has progressed in recent years. It also demonstrates that, although the contributions of Islamic science remain largely unappreciated, modern studies show that productive, original scientific research continued, at least, up to the sixteenth century in the Islamic empire. Clearly, such a scientific effort merits the attention of scholars.

Chapter Three examines the nature of an ideal scholarly community, and the qualitative standards that it needs for, and the constricting problems that may hinder, the production of reliable knowledge. It examines the type of a scholarly community, which would be necessary to study the fate of Islamic science. It sketches a rough outline of an ideal scholarly community; in the way some scholars define it. The point of Chapter Three is not to develop a new set of qualitative standards of a scholarly community, nor a new set of qualities of a true scholar, but to utilise a certain conception of it in order to bring out more clearly why these standards are needed to measure adequacy of scholarship. This chapter examines the qualitative standards of a scholarly community and the way it is supposed to – ideally – function. The aim is to show that members of a true scholarly community would – amongst other things – communicate effectively; show awareness, and criticism, of each others work; accumulate evidence; use mutually understood terms; discuss and adopt or reject certain terms and concepts; and develop more sophisticated concepts. Also, the aim is to show that a scholar should – amongst other things – have integrity, objectivity and fairness. Explanation of how constraining factors can hinder the production of valid knowledge will also be made. It is on the basis of this understanding that Chapter Four seeks to examine the adequacy of the scholarly community in understanding and describing the fate of Islamic science between the eleventh and sixteenth centuries.

Chapter Four presents the first comprehensive review of scholarship on the fate of Islamic science between the eleventh and sixteenth centuries. The chapter does not review studies on specific topics, but those that make general statements about the fate of Islamic science. The review begins with the primary work of Ibn Khaldun's *al-Muqaddimah*, and moves on to cover the ideas of some of the most prominent scholars leading to our present time – such as Sarton, al-Hassan, Saunders, Sayili, Sabra and Saliba. For the first time, Ibn Khaldun's theory on the fate of Islamic science is comprehensively presented here. The intent of Chapter Four is to demonstrate that there are diverse opinions to describe what happened to Islamic science, such as: "decline," "decadence," "stagnation," "fragmentation," "standstill," and that Islamic science "froze." It shows that the decline theory is the most prominent and persistent of all. The most interesting finding of the chapter, however, is that six centuries ago, Ibn Khaldun provided a more sophisticated and complex theory regarding what happened to Islamic science, the awareness of which was largely unnoticed.

Chapters Five, Six, Seven, and Eight constitute the practical aim of the thesis, where four case studies of distinct branches of Islamic science, belonging to different geographical areas, will be examined. No special plan or principle of selection governed the choice of these case studies, except that the branches of Islamic science chosen are, perhaps, the most researched. All these case studies are drawn from the context of modern studies in the history of Islamic science. The aim of examining these branches of Islamic science is to see how far they fit into the theoretical claims established in Chapter Four. For the period between the eleventh and sixteenth centuries, Chapter Five examine the fate of mathematics in the Maghrib; Chapter Six examines the fate of astronomy in Persia; Chapter Seven examines astronomy in Egypt and Syria; and Chapter Eight examines medicine in Egypt and Syria. Examination of evidence for specific areas shows that different fates awaited Islamic science in different areas at different times. Certainly, the case studies show that there is no evidence of a general decline, and it is clear that Islamic science flourished for centuries after the eleventh century.

Chapter Nine discusses the reasons for the failure of the scholarly community in understanding what happened to Islamic science, and why mistaken theories, such as the decline theory, persisted for a long time and remain in use. This chapter consists of a number of hypotheses about the processes occurring at various junctures in the production, reception, assessment, and dissemination of scholarly knowledge. These hypotheses will be supported with evidence gathered in the previous chapters, and at other times will be backed up by our understanding of the nature of the scholarly community described in Chapter Three. Amongst other things, this chapter argues that understanding of the theory of the decline of Islamic science is a social misconstruction of reality, referring here to a collective error, to a widespread agreement about facts or interpretation that is mistaken.[55]

Chapter Ten argues that a comprehensive approach to the study of the fate of Islamic science is clearly needed, one that examines both the cultural, environmental, and the interaction among different cultural dynamics at work.

[55] *Ibid.,* p.1.

However, since so many original documents on Islamic science have not yet been examined, it is not possible to state with confidence what the final model will look like. But, on the basis of what is known, some tentative generalisations are made. The Conclusion, Chapter Eleven, reflects on a few of the limits of the study, its originality, and suggests directions for future research.

The next chapter will show that a huge and brilliant entity, the Islamic Empire, did a great deal of science. The chapter also highlights some of the ways in which classical and contemporary scholars have understood the importance of Islamic science, and how this understanding has progressed in recent years

2

THE IMPORTANCE OF ISLAMIC SCIENCE: PROGRESSIVE UNDERSTANDING IN THE SCHOLARLY COMMUNITY

INTRODUCTION

The aim of this chapter is to point out some of the more absurd ideas in the past about Islamic science and demonstrate that – even using western criteria – much excellent science was done in the Islamic Empire. The chapter highlights some of the ways in which classical and contemporary scholars have understood the importance of Islamic science, and how this understanding has progressed in recent years. It also demonstrates that, although the contributions of Islamic science remain largely unappreciated, modern studies show that productive, original scientific research continued, at least, up to the sixteenth century in the Islamic empire. The aim is to show that Islamic science is worthy of specialist study in its own right, rather than as a backdrop to, or a counter-example to, western science. This chapter is organised in the following manner. Section one briefly outlines how modern research in Islamic science has shifted scholars' understanding of the importance and contribution of Islamic science. Section two gives a brief overview of the importance, contribution and originality of Islamic mathematics, astronomy and medicine. Section three gives some concluding remarks.

1. Islamic Science: Progressive Understanding In The Scholarly Community

Islamic science was originally viewed as a mere translator and transmitter of Greek, Indian and pre-Islamic Persian science, with no original contributions or impact on the grand narrative of the history of science. In his book, *Astronomical Centres of the World*, Kevin Krisciunas explains that literature on the history of astronomy usually propagate a common misconception, which postulate that: "astronomical research fell into a dazed slumber following Ptolemy (the Greek scientist who lived long before Islam), not to reawaken until the time of Copernicus."[1] Accordingly, some Western historians of astronomy, such as Neugebauer and Delamere, find nothing to report about Islamic astronomy.[2] Others like the distinguished physicist-philosopher-historian Pierre Duhem (1861-1916), suggested that:

> The revelations of Greek thought on the nature of the exterior world ended with the "Almagest," (by Ptolemy) which appeared about A.D. 145, and then began the decline of ancient learning. Those of its works that escaped the fires kindled by Mohammedan warriors were subjected to the barren interpretations of Mussulman [Muslim] commentors and, like parched seed, awaited the time when Latin Christianity would furnish a favourable soil in which they could once more flourish and bring forth fruit.[3]

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[1] Kevin Krisciunas, *Astronomical centres of the World* (Cambridge: Cambridge University Press, 1988), p.23.

[2] Salah Zaimeche, "A Review on Muslim Contribution to Astronomy," *Foundation for Science, Technology and Civilisation*. http://www.muslimheritage.com/topics/default.cfm?ArticleID=233. (22/5/2003).

[3] *Ibid.*

In other words, Muslims "were fanatic, rampaging hordes, burners of Greek science, and also pale imitators, copiers of the Greeks."[4] Duhem even denied the existence of what he called 'Arabian science.' He believed that, "There is no Arabian science. The wise men of Mohammedanism were always the more or less faithful disciples of the Greeks, but were themselves destitute of all originality."[5]

On the other hand, the influential French philologist, Ernest Renan (1823-1892), believed that Islamic science could only flourish in association with heresy, and that, "science in Islam was merely parasitic on Greek culture and that Islam was simply a vehicle transmitting Greek philosophy to the Renaissance in Europe."[6] Other classical historians repeated this view. Von Grunebaum, for example, suggested that Islamic science was a mimic of Greek science, and asserted that Islam failed to "put natural resources to such use as would insure progressive control of the physical conditions of life. Inventions, discoveries, and improvements might be accepted but hardly ever were searched for."[7]

According to critics such as Bryan S. Turner[8], Ziauddin Sardar[9] and the late Edward Said,[10] the above views about Islamic science are a product of what is

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[4] *Ibid.*

[5] Quoted in David C. Lindberg, *The Beginning of Western Science: The European Scientific Tradition in Philosophical, religious, and institutional Context, 600 B.C. to A.D. 1450*," (Chicago: The University Chicago Press, 1992), p.175.

[6] Ernest Renan (ed.), "Islamism and science," *Poetry of the Celtic Race and Other Studies* (London: W. Scott, 1896), p.85 quoted in Bryan S. Turner, *Orientalism, Postmodernism & Globalism* (New York: Routledge, 1994), p.31.

[7] Grunebaum in Turner, *ibid.,* p.71.

[8] Professor of Sociology at the University of Cambridge.

[9] Currently, he is Consulting Editor of *Futures*; visiting professor of science and technology policy at the Middlesex University.

[10] He was one of the most important literary critics alive, a professor of English and comparative literature at Columbia, the author of 15 books, a music critic, a scholar of opera and a pianist. He has been a major force in recreating the field of literary studies over the past two decades. His work helped give form to entire new scholarly areas, like postcolonial theory. His 1978 book, *Orientalism*, revolutionized the study of the Middle East and has been argued over bitterly for

called 'Orientalism.' Orientalism "treats the Orient and Orientals as an 'object' of study inscribed by Otherness."[11] This typology, argues Abdel-Malek, is "based on a real specificity but detached from history, and thus conceived as intangible and essential."[12] According to Sardar, this typology ensures that: "European man, from Greek antiquity onwards, becomes the measure of all men everywhere."[13] Accordingly, Islamic contributions to science were deliberately ignored or suppressed,[14] and the view that Islamic scientists produced nothing original remained orthodox belief until the mid-twentieth century.[15]

Specialists in the history of Islamic science, such as Saliba, believe that the above negative views regarding Islamic science are "at best a caricature of history, one that portrays the "torch" of science and knowledge as something that was handed down from the ancient Greeks to medieval Europe by way of Islamic scholars."[16] The danger of this representation is that it "miscasts the role of the Islamic civilisation in the scientific revolution and undermines the often deep relation between cultures and intellectual movements."[17] In addition, it allows historians of classical science to conclude that, "science as theory is Greek and as experimental method it was born in the seventeenth century,"[18] thereby neglecting the contributions of Islamic scholars in between. This approach, explains Rashed:

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years.

[11] Abdel-Malek (1981) quoted in Ziauddin Sardar, *Orientalism* (Buckingham: Open University Press, 1999), p.59.

[12] *Ibid.*

[13] *Ibid.*

[14] *Ibid.*,p.60.

[15] *Ibid.*, p.50.

[16]George Saliba, "Greek Astronomy and the Medieval Arabic Tradition," *American Scientist*, 90, 2002, p.360.

[17] Roshdi Rashed (ed), "Preface," *Encyclopaedia of the history of Arabic Sciences*, 3, (London: Routledge, 1996), p. x.

> Has frequently ended up misrepresenting the results of Greek science as well as those of the seventeenth century, a necessary distortion if one wishes to link the two ends of the chain in a continuous history; on the other hand, and not without coincidence, it has led to some famous blunders affecting not only interpretation but comprehension too.[19]

Recent research has shifted scholars' understanding about Islam's contribution to the exact sciences. According to Jan P. Hogendijk and Sabra, the bulk of Greek science, medicine and philosophy were "appropriated" by the Islamic civilisation during the eighth and ninth centuries.[20] This was achieved through "a process of translation from Pahlavi, Sanskrit, Greek, and Syriac, in the course of which Arabic became the language of a rich and active scientific and philosophical tradition for many centuries."[21] The eleventh and twelfth centuries marked the period of translating the Arabic scientific works from Arabic into Latin, and "in turn were appropriated into the Latin medieval culture."[22] It is now known that "between AD 800 and 1450, the most important centres"[23] for the study of what is now called "the exact sciences were located in the vast multinational Islamic world."[24]

Ahmed Djebbar, professor of History of Mathematics in North Africa and Muslim

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[18] *Ibid.*
[19] *Ibid.*
[20] Jan P. Hogendijk and Abdelhamid Sabra (eds.), *The Enterprise of Science in Islam: New Perspectives* (Cambridge: The MIT Press, 2003), p.vii.
[21] *Ibid.*
[22] *Ibid.*
[23] *Ibid.*
[24] *Ibid.* According to Hogendijk and Sabra the exact sciences denote "the mathematical sciences of arithmetic, geometry and trigonometry, and their applications in various fields such as astronomy, astrology, geography, cartography, and optics, to mention only some of the more prominent examples."

Spain, explains that the originality of Islamic science was not the "fruits of chance meetings, but the deliberate results of a massive movement of scientific and philosophical translation, undertaken by professionals – sometimes rivals – supported by power and stimulated by the research itself."[25] This movement resulted in the creation of a "library on the scale of the world of its time."[26] Hence, for the first time scientific traditions from different backgrounds and languages became elements of one science, whose language was Arabic, and found ways of reacting together to bring about new methods, and sometimes even new disciplines,[27] such as trigonometry, algorithms and algebra.

Nevertheless, according to David King, specialist on medieval Islamic science, Arabic scientific manuscripts and medieval Islamic and European scientific instruments, the most widely used American University textbook for the history of science "shows no interest in Islamic science *per se* and ignores most of the research on Islamic science conducted during the past 50 years."[28] Europe has no textbook that even mentions Islamic science.[29] Only recently has the Western scholarly community produced a substantial amount of reliable literature on the subject, some even for the general reader, for example, *The Encyclopaedia of the History of Arabic Science* (1996), which contains a series of chapters on different branches of Islamic science.[30] And the 2003 publication edited by Jan P. Hogendijk and Abdelhamid Sabra, *The Enterprise of Science in Islam: New*

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[25] Ahmed Djebbar, *Une Histoire de la science arabe, entretiens avec Jean Rosmorduc (A History of Arab Science -- Conversations with Jean Rosmorduc)* (Paris: Seuil, 2001), in David Tresilian, "Creeker than the Greeks," *Al-Ahram Weekly Online*, 10 - 16 January 2002, Issue No.568. http://weekly.ahram.org.eg/2002/568/bo5.htm p.xi.

[26] *Ibid.*

[27] *Ibid.*

[28] David A. King, "Proposal for an exhibition on Islamic science and technology," *UNESCO*, 1997, http://www.unesco.org/science/pao/exhib/islam2.htm#1

[29] *Ibid.*

Perspective, which offers an overview of the newly energised field of historical investigation on Islamic science, with emphasis on the transmission of scientific knowledge, either from one culture to another or within the medieval Islamic world. The contributions of Islamic scientists are even less well understood in the Islamic world itself.[31] No serious modern work of a general nature on Islamic science is available in Arabic, except Saliba's 1998 Arabic book, *The Origin and Development of Arabic Scientific Thought*. Here, Saliba explains that most of the results of the last fifty years' research on Islamic science has not reached the Arab reader, let alone any serious discussion on the topic. In addition, whatever is being repeated in Arabic texts on this topic is old, usually erroneous, or subject to correction.[32]

Hogendijk and Sabra explain that a huge amount of "source material is now available in the form of unpublished manuscripts in Arabic, Persian, and other languages in libraries all over the world."[33] However, only few of the surviving major scientific works have been translated, and modern scholars have never read thousands of these manuscripts.[34] Simply put, the history of Islamic science as a field remains virgin territory,[35] and "the time is not yet ripe for a reliable survey of the entire field."[36] As little as is known about Islamic science, still new discoveries of the last few decades are rapidly changing scholars' views on the importance of Islamic science.[37]

[30] *Ibid.*
[31] *Ibid.*
[32] George Saliba, *The Origin and Development of Arabic Scientific Thought* [Arabic] (Lebanon: Balamand University, 1998), p.15.
[33] Hogendijk and Sabra, *The Enterprise of Science in Islam: New Perspectives*, o*p. cit*., p.vii.
[34] King. "Proposal for an exhibition …" *op.cit.*
[35] D. Overbye, "How Islam won, and Lost, the lead in science," *Science Times*, 2001.
[36] Hogendijk and Sabra, *op.cit*., p.vii.
[37] *Ibid.*

2. ISLAMIC MATHEMATICS, ASTRONOMY AND MEDICINE IN THE LIGHT OF MODERN RESEARCH: BRIEF OVERVIEW

The aim here is to show that in key areas, modern research is showing that genuine high quality science was done in at least some scientific disciplines. Islamic scientists worked on such a variety of topics that to focus on mathematics, astronomy and medicine only certainly does injustice to other areas in which they exercised their high quality contributions. Islamic scientists contributed to a colourful array of fields including physics, chemistry, cosmology and cosmography, cartography and geography. To ignore these is to impoverish the history of Islamic science. Therefore, mathematics, astronomy and medicine are chosen here because modern research has shown that original and high quality science was done in these areas.

MATHEMATICS

Islamic Mathematicians first acted as "transmitters"[38] of almost all the important mathematical ideas of Mesopotamia, Egypt, Greece, India, Persia and the Hellenistic world.[39] Eventually they "added their own contribution, and this time an absolutely momentous one,"[40] which directly influenced arithmetic, geometry, algebra, and algorithms. Before learning of the Indian numerals and the 'dust-board' system early in the eighth century from Indian and Persian sources, the

[38] T. Goldstein, *Dawn of modern science* (Boston: Houghton Mifflin Co., 1980), p.120.
[39] S. H., Nasr, *Islamic science: An Illustrated Study* (Westerham: Westerham Press, 1976), p.77.
[40] Goldstein, *op.cit.,* p.120.

Muslims used finger computation,[41] also called "arithmetic of the scribes" or "secretaries" because it was intended for the use of the government bureaucracy. This Indian system was able to express any number, however large, using only ten figures including an empty place for zero, and the results were written out in words.[42] Islamic scientists recognised the importance of the Indian system and thus transformed it into the well-known 'Arabic numerals,'[43] which are still in use today in the West, through which "the West has been able to make its giant mathematical strides."[44] The Arabic numerals became:

> …an intensely workable code, one so simple that literally any child can handle it, so flexible that in the hands of the mathematicians it became a vocabulary by which the most complex relations between the most astronomical quantities can be expresses…It was a revolution on a par with the invention of the computer; one was able to reduce the cosmos to a system of ten elementary symbols, from zero to nine.[45]

Recently, in his chapter "The Transmission of Hindi-Arabic Numerals Reconsidered,"[46] Paul Kunitzsch accepts "the usually cited evidence presented by the Arabic and Syriac sources in support of the thesis that the nine numerals plus a symbol for an empty place initially came to the Arabs from India in the eight

[41] Nasr, *Islamic science: An Illustrated Study*, *op.cit*., p.78.
[42] H. R. Turner, *Science in Medieval Islam: An illustrated introduction* (Austin: University of Texas Press, 1995), p.45.
[43] *Ibid*., p.78.
[44] Goldstein, o*p.cit*., p.120.
[45] *Ibid*., p.121.
[46] Paul Kunitzsch, "The Transmission of Hindi-Arabic Numerals Reconsidered," in Jan P. Hogendijk and Abdelhamid Sabra (eds), *The Enterprise of Science in Islam: New Perspectives*. (Cambridge: The MIT Press, 2003), pp.3-23.

century."[47] He rejects, however, the hypothesis that was proposed by S. Gandz, "the dust board utilised by the Arabic mathematicians for performing their calculations later became the model for the Latin abacus."[48]

Islamic mathematicians invented powerful new methods of numerical computation that reached their height with the fourteenth/fifteenth century mathematician Ghiyath al-Din al-Kashani.[49] And they dealt with decimal fractions, numerical series, and similar branches of mathematics related to numbers.[50] The Arabic numerals were first transmitted and used in the West for the first time in the latter half of the twelfth century through the translation of the first part of al-Khawarizmi's *The Book of Addition and Subtraction in Indian Arithmetic*, which survives as a translation only.[51] By this time, many other important works in Arabic were well ahead of the West, including the work of al-Karaji (around 1000), 'Umar al-Khayyam (d.1130), as-Samaw'al (d. around 1175), and Ibn al-Haytham (d. around 1040).[52]

Islamic mathematicians also advanced the science of geometry of the Greeks. They utilised their newly sophisticated geometry in "surveying, in designing wheels of all kinds, including waterwheels and other systems for drawing water, in improving farming equipment, and, inevitably, in devising engines and devices of war, such as catapults and crossbows."[53] In the ninth century, Thabit ibn Qurra wrote on "cubatures and quadratures and used the method of exhaustions in a

[47] *Ibid*., p.ix.
[48] *Ibid*
[49] S. H. Nasr, *Science and Civilisation In Islam* (New York: Plume Books, 1968), p.152.
[50] *Ibid*
[51] Nasr.,*Islamic science: An Illustrated Study*, *op.cit*., p.78.
[52] *Ibid.*
[53] Turner*, op.cit.,* p.47.

manner, which anticipates the development of integral calculus."[54] He also advanced the study of parabolas, and used integral sums to find the area of a segment of parabola.[55] He translated the *Conics* of Appollonius, a number of treatises of Archimedes, the *Introduction to Arithmetic* of Nicomachus,[56] and calculated the "volume of the parabolic, and gave a geometrical solution to some third degree figures."[57] Umar al-Khayyam and al-Tusi "re-examined the fifth postulate of Euclid concerning the parallel line theorem, which concerns the very foundation of Euclidean geometry."[58] Though they did not claim to challenge Euclid's postulates, their work eventually "led to G. Saccheri's first attempt to formulate a non-Euclidean geometry (1733)."[59]

While the Greeks had calculated "a table of chords," Islamic scientists invented trigonometry – both plane and solid.[60] They were also the first to formulate explicit trigonometric functions.[61] The first scientist to use tangents (*zill*) was the astronomer Habash al-Hasib, who also knew of the Sine, Cosine, and Cotangent functions.[62] More influential was Abu'l-Wafa al-Buzanji, the first person to demonstrate the sine theorem for a general spherical triangle,[63] and to invent the secant (*qutr al-zill*). The latter discovery is usually attributed to Copernicus.[64] Al-Biruni wrote the first independent work on spherical trigonometry, calculated the approximate value of a diagonal of one degree, and was the first to demonstrate

[54] Nasr, *Islamic science: An Illustrated Study*, *op.cit*., p.82.
[55] *Ibid.*
[56] *Ibid.*
[57]Nasr, *Science and Civilisation In Islam*, *op.cit*. p.149.
[58] Nasr. *Islamic science: An Illustrated* Study, op.*cit*., p.82.
[59] *Ibid.*
[60] *Ibid.*
[61] *Ibid.*
[62] *Ibid.*
[63] *Ibid.*
[64] *Ibid.*

that for a plane triangle $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$.[65]

They also invented algebra. Muhammad ibn Musa al-Khawarizmi (780-850), the greatest of all Muslim mathematicians, is known for being "instrumental in converting Babylonian and Hindu numerals into a simple and workable system that almost everyone could use."[66] He is also best known for originating the mathematical terms and concepts of algebra and Algorithm[67] (which is derived from his name al-Khawarizmi). He composed many astronomical tables and also worked on arithmetic and algebra,[68] and is recognised as the founder of Algebra for he initiated the subject in a systematic form and developed it to the extent of giving analytical solutions of linear and quadratic equations.[69]

His book on algebra, *The Book of Summary concerning the Process of Calculating Compulsion and Equation*, was used until the sixteenth century as the principle textbook of European universities.[70] And it is from its title that the name algebra (*al-Jabr* meaning restoration and amplification of something incomplete and *Muqabala* the balance of two sides of an equation) was derived.[71] The Toledan translation of his book, *Algorismi de numero indorum*, had a profound impact upon the West and gave English such words as algorithm and cipher (Arabic for "zero") and the Spanish word guarismo.[72]

[65] *Ibid.*
[66] Turner, *op.cit.,* p.47.
[67] *Ibid.*
[68] *Ibid.*
[69] *Ibid.*, p.79.
[70] Hitti in C. A. Qadir, *Philosophy and science in the Islamic world* (London: Croom Helm Ltd., 1988.) , p.115.
[71] Nasr, *Islamic science: An Illustrated Study*, *op.cit*., p.85.
[72] *Ibid.,* p.79.

One of the many other mathematicians, the Persian Ghiyath al-Din Jamshid al-Kashani, devised a theory of numbers and techniques of computation that remained unmatched until recently.[73] He also rediscovered the decimal fraction, initially discovered by al-Uqlidisi and then forgotten for centuries,[74] made a remarkably accurate calculation of π, is considered the first person to invent a calculating machine, and the first person to solve the Newton binomial theorem.[75]

ASTRONOMY

Régis Morelon explains, "Interest in astronomy has been a constant feature of Arabic culture since the end of the eighth century, and it is the quantity of study which strikes us first when we begin exploring this subject."[76] Recent research in the history of astronomy in Islam demonstrates that medieval Islamic astronomers were not mere translators but may have also played a key role in the Copernican revolution,[77] which ultimately influenced the Renaissance. The contribution of Islamic science was fundamental to the birth and subsequent development of astronomy in the West.[78] The West had no advanced astronomy before this contribution.[79] The knowledge developed by Islamic astronomers produced changes in the Latin West as regards the development of trigonometry,

[73] Qadir, *op.cit.*, p.115.
[74] *Ibid.*
[75] Nasr, *Islamic science: An Illustrated Study*, *op.cit.*, p.80.
[76] Régis Morelon, "General survey of Arabic astronomy," in Roshdi Rashed (ed.). *Encyclopedia of the History of Arabic Science* (London: Routledge, 1996), vol.1, p.1.

[77] Saliba, "Greek Astronomy and the Medieval Arabic Tradition," *op. cit.*, p.360.
[78] Henri Hugonnard-Roche, "The Influence of Arabic astronomy in the medieval West" in Roshdi Rashed (ed), *Encyclopaedia of the history of Arabic sciences* (London: Routledge, 1996), 1, p.284.
[79] *Ibid.*

instruments and the Latin catalogues of stars, and also affected the growth and development of astronomical theory proper.[80]

Astronomy was a practical science for the Muslims, because they used the stars as guides during their travel. Thus, astronomy became one of their greatest achievements. Its practical importance was also emphasised by the need to determine the prayer direction (*qibla*) and time, regardless of one's location.[81]

Islamic astronomers surpassed the Greek mathematical methods,[82] and developed trigonometry, which eventually provided the essential tools for the astronomy that developed during the Renaissance.[83] Medieval Islamic astronomers felt themselves challenged to find a simpler trigonometric method than that postulated by such astronomers as Ptolemy.[84] As with mathematics, the study of astronomy was influenced by ancient sources, and Muslims were acquainted with Indian and Persian before Greek ones. The Persian Sassanids astronomical treatises were translated into Arabic during the eighth-century.[85] Ptolemy's work was introduced in the ninth century. Around that time, scholars such as Thabit ibn Qurra and Hunayn ibn Ishaq translated Ptolemy's major work *Megalé syntax mathematiké* (Almagest in Arabic).[86] By the end of the ninth century, the Arabs had thoroughly studied and were acquainted with the work of antiquity.[87]

Scientists at the famous al-Maragha observatory in western Iran greatly influenced

[80] *Ibid.*
[81] Nasr, *Islamic science: An Illustrated Study*, *op.cit*., p.92.
[82] *Ibid.*
[83] *Ibid.*
[84] *Ibid.*
[85] *Ibid*., p.97.
[86] *Ibid.*

Copernican astronomy, whose work led to the development of planetary systems that was mathematically equivalent to that of Copernicus. Such closeness caused Noel Swerdlow to ask "not whether, but when, where, and in what form" Copernicus learned of the Maragha scientists.[88] Advances in planetary theories were primarily the result of criticising Ptolemy's work, which had dominated the field from the time of al-Battani.[89] While refining and improving the work's details, rising dissatisfaction with many of its aspects led scholars like Nasir al-Din al-Tusi, Qutb al-Din al-Shirazi, and Ibn al-Shatir to criticise the Ptolemaic (geocentric) system in the twelfth and thirteenth centuries. This criticism was, to some extent, very important "in the later attacks made against him during the Renaissance in the West."[90] The work of astronomers like Ibn al-Shatir allows modern scholars like Saliba to conclude that "at some level the Renaissance – which was at least partly inspired by the Copernican revolution – was not a purely European creation."[91] According to him, "the role of Arabic astronomy was not to preserve Greek astronomy, but to correct its flaws and finally to seek alternatives to it."[92]

Thousands of Arabic manuscripts in major libraries remain unknown to scholars.[93] However, eminent scholars like Saliba and David King have advanced our understanding of the originality and influence of Islamic astronomy. Unlike the traditional view that Islamic astronomers accepted the Greek work as

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[87] *Ibid.*
[88] N. Swerdlow and O. Neugebauer, *Mathematical Astronomy in Copernicus's "De revolutionibus.* (New York: Springer Verlag, 1984), cited in Toby Huff, *The Rise of Early Modern Science*. (Cambridge: Cambridge University Press, 1993), p.54.
[89] Nasr, *Islamic science: An Illustrated Study*, *op.cit*., p.106.
[90] *Ibid.*
[91] Saliba, "Greek Astronomy and the Medieval Arabic Tradition," *op. cit.* p.360
[92] See: "In defence of Copernicus. (Letters to the Editors)," *American Scientist*, 90, 6, Nov-Dec 2002, p.492 (1).

unalloyed truth, they in fact rejected much of it and forged a new astronomy that, later on, enabled Copernicus to lay the foundation of modern astronomy.[94] Consequently, the original contributions made by Islamic astronomy challenge the idea that Islamic science only transmitted ancient Greek science and knowledge to medieval Europe without adding anything.

MEDICINE

Medicine is particularly difficult as a theorising science because of the complexity of its subject matter.[95] Medicine existed as a practical craft in all human societies for dealing with sickness or bodily injuries.[96] In early primitive societies the techniques that were used were based upon rational religious basis about evil spirits or have intelligible roots in systematic magic.[97] The skills required to learn these crafts were often passed on from father to son, and not learnt from books or a college curriculum.[98]

Hippocrates (around 400 BC) was the first to make a systematic expounding of the practice of medicine as a rational art.[99] His work was remarkable for its observational accuracy and objectivity. Hippocrates' influence upon Greek medicine made it reach a sophisticated level of skill so that the "healing power of the physician lay in his long apprenticeship and personal experience rather than in any particular formula which can be looked up in a book."[100] The fact that these

[93] Saliba, "Greek Astronomy and the Medieval Arabic Tradition," *op. cit.*, p.360
[94] *Ibid.*
[95] John Ziman, *The Force of Knowledge The Scientific Dimension of Society* (Cambridge: Cambridge University Press, 1976), p. 146.
[96] *Ibid*
[97] *Ibid*
[98] *Ibid.,* pp.147-148.
[99] *Ibid.*
[100] *Ibid.*, p.150.

writings became public knowledge was "a decisive step forward in the development of scientific medicine, for it encouraged the publication of new observations, new techniques and new theories."[101] From the Hippocratic tradition arose the extensive and competent medical technique of the Roman Empire. The most important figure of that time was Galen (AD 131-200), whose work in medicine was an authority for the next 1300 years. Galen was an outstanding investigator, who is considered as the founder of the science of anatomy. Despite many errors, his works were taken to be the literal truth. This Hellenistic medicine was passed into the Islamic Empire, where Galen's work was criticised and drastically improved.[102]

Islamic medicine was built on tradition, mainly the theoretical and practical knowledge developed in Greece and Rome. For Islamic scholars, Galen and Hippocrates were pre-eminent authorities,[103] followed by Hellenic scholars in Alexandria. Muslim and non-Muslim scholars translated the voluminous writings from Greek (Hippocrates, Dioscorides, and Galen) into Arabic, thus providing virtually all of Islam's early medical students with their basic reference texts.[104] Basing themselves upon these texts, they produced new medical knowledge. In order to make ancient medical works more accessible, understandable and teachable, these scholars ordered and made more systematic the vast and sometimes inconsistent Greco-Roman medical knowledge by writing encyclopaedias and summaries.[105]

[101] *Ibid.*
[102] *Ibid.*
[103] Turner., *op. cit.*, p.131.
[104] *Ibid.*, p.132.

The novelty of Islamic medicine does not lie in the mass of information that it conveyed to the West via Arabic translations, but in the way it helped "medicine to become established as a science."[106] Translations of Arabic medical manuscripts "gave a decisive direction to the teaching of medicine in the West."[107] After the rather rapid assimilation[108] of the medicines of previous civilisations, Islamic medical writings became "more systematic and synthetic, with an evident urge to produce the most comprehensive and complete medical reference work yet written."[109] A primary concern of Islamic medical scholars was the "organisation of the vast body of knowledge into a logical and accessible format."[110] They also expanded theoretical discourses on causes and symptoms, and frequently introduced examples and procedures of an applied character.[111] A considerable body of medical works was being taught systematically. Great hospitals were founded in major Islamic cities, where the teaching of medicine went on along with the care for the sick. These hospitals constituted "veritable schools, with a more permanent institutional character than a single practitioner with a few apprentices or pupils."[112] It was in this historical background that Islamic medicine developed and advanced to become scientific, and at its zenith many towering physicians appeared.

Abu Bakr Muhammad Ibn Zakariya al-Razi, (865-925), known in the West by the Latin name Rhazes, is known as the "keenest original thinker and greatest

105 *Ibid*
106 Danielle Jacquart, "The influence of Arabic medicine in the medieval West," in Roshdi Rashed (ed), *Encyclopaedia of the history of Arabic sciences* (London: Routledge, 1996), vol.3, p.963.
107 Howard, *op. cit*., p.132.
108 Emilie Savage-Smith, "Medicine," in Roshdi Rashed (ed), *Encyclopaedia of the history of Arabic sciences* (London: Routledge, 1996), vol.3, p.913.
109 *Ibid.*
110 *Ibid.*
111 *Ibid.*

clinician not only of Islam but of the Middle Ages."[113] He was the greatest original clinical and observational physician.[114] Al-Razi and Ibn Sina "must rank among the greatest physicians of all time".[115] In selecting a new site for the great hospital in Baghdad, Al-Razi hung up shreds of meat in different places, choosing the spot where they showed the least sign of putrefaction.[116]

Al-Razi applied chemistry and physics to medicine. He wrote a medical encyclopaedia and another treatise on smallpox and measles,[117] which was "the earliest of its kind and rightly considered an ornament to the medical literature of the Arabs."[118] Al-Razi was a pioneer in the fields of paediatrics, obstetrics and ophthalmology. His treatise *The Disease Of Children* has led some historians to regard him as the father of paediatrics.[119] He is also considered the inventor of the Seton in surgery.[120] He is also considered the first to: relate hay fever to the scent of rose;[121] isolate and use alcohol (Arabic *al-Kuhool*) as an antiseptic; use mercury as a purgative, which became known in the Middle Ages as "Album Rhasis;"[122] give an account of the operation for the extraction of the cataract, and discuss the papillary reaction or the widening and narrowing of the pupil of the eye. Furthermore, al-Razi achieved mastery of treatment by means of

[112] Ziman, *op.cit*., pp.152-153.
[113] Phillip K. Hitti, *The Arabs – A Short History* (London: Macmillan, 1968), pp.109-110; Howard, *op. cit*., p.135.
[114] S. H. H. Nadvi, *Medical Philosophy in Islam and the Contributions of Muslims to the advancement of medical sciences* (Durban: Academia, 1983), p.30-31.
[115] Turner, *op. cit*., p.135.
[116] Hitti, *op. cit*., p.110.
[117] *Ibid.*
[118] *Ibid.*
[119] *Ibid.*
[120] Hitti, *op. cit*., p.110.
[121] Savage-Smith, Emilie, "Gleanings from an Arabist's Workshop: Current Trends in the Study of Medieval Islamic Science and Medicine," *Isis*, 79, 1988, pp. 246-72.
[122] Nasr, *Science and Civilisation In Islam*, *op. cit*., p.207.

psychological shock.[123] He was a master of psychosomatic medicine and psychology. In its English translation, al-Razi's book *Spiritual Physick* devoted twenty chapters to various ailments that upset the soul and the body.[124]

Al-Razi wrote many books on medicine, the major ones include *al-Hawi fi'l tibb*, (*The Comprehensive Book*), an encyclopaedic composition of Greek, Persian and early Arabic medical knowledge in their entirety, whose "modern version [*sic*] is incomplete at 23 volumes."[125] The Sicilian Jewish physician Faraj (Farragut) bin-Salim was the first to translate *Al-Hawi* to Latin in 1279. Under the title *Continens* it was repeatedly printed from 1486 onwards, a fifth edition appeared in Venice in 1542.[126] Prior to the nineteenth century, *Al-Hawi* can be considered one of the most extensive medical texts written by a doctor.[127]

Another of his books is *Kitab al -Mansoori* (known by the Latin title *Liber medicinalis ad Almansori*), was translated in 1480 by Milan. It was also translated into French and German. It comprised ten volumes, the ninth of which translated by Gerard of Cremona under the title *Nonus al-Manuri*, was popular in Europe until the sixteenth century.[128] In this book the science of anatomy was developed, in which al-Razi deals with veins, arteries, disposition of the heart etc.[129]

His famous book on Smallpox and Measles, or *Kitab fi* a*l-Jadari wa-al-Hasbah*

[123] Nadvi, *op. cit*., p.31
[124] *Ibid.*
[125] Savage-Smith, "Gleanings from an Arabist's Workshop…" *op. cit.,* p.246.
[126] Hitti, *op. cit*., p.110.
[127] Turner, *op. cit*., p.136.
[128] Savage-Smith, "Gleanings from an Arabist's Workshop…" *op. cit.,* p.256.
[129] Nadvi, *op. cit*., p.31.

known in Latin as *Liber de Pestilentia*,[130] was very influential in Europe. First translated into Latin in 1565 and later into many other European languages. Forty editions were printed between 1498 and 1866.[131] In 1848 William A. Greenhill translated it into English. Through this treatise he became the first to draw clear comparison between smallpox and chickenpox.[132] This treatise "demonstrates quite well his concern for therapy, and its thoroughness stands in sharp contrast to the silence regarding the topic in the Hellenistic and Byzantine literature preserved today."[133]

Another great figure, Ibn Sina, known in the West, as Avicenna was the most renowned physician, philosopher, encyclopaedist, mathematician and astronomer of his time. According to George Sarton Ibn Sina's "thought represents the climax of medieval philosophy."[134]

One of his major contributions to medicine was his famous book *al-Qanun fi'l-tibb* (*The Canon of Medicine*), which was an immense encyclopaedia of medicine. It contains some of the most illuminating thoughts pertaining to "distinction of mediastinitis from pleurisy; contagious nature of phthisis; distribution of diseases by water and soil; careful description of skin troubles; of sexual diseases, and perversions; of nervous ailments (including love sickness; many psychological and pathological facts clearly analysed."[135] Ibn Sina deals with general principles

[130] *Ibid*., p.3.
[131] Max Meyerhof, " Science and Medicine," in Sir Thomas Arnold and Alfred Guillaume (eds). *The Legacy of Islam* (Oxford: Clarendon Press, 1931), p.323.
[132] *Ibid.*
[133] Savage-Smith, "Medicine," *op.cit*., p.914.
[134] George Sarton, *Introduction to the History of Science* (New York: Robert Krieger Publishing Company, 1975), Vol.1, p.709.
[135] *Ibid*.

of medicine; simple and compound drugs containing 760 types of drugs;[136] disorders of each internal and external organ of the body;[137] diseases effecting all of the body, especially pathology pharmacopoeia.

The *Canon* influenced the medical schools of Europe for the next six hundred years,[138] and it was "probably the most used of all medieval medical references."[139] Gerard of Cremona translated the *Canon* in the twelfth century. During the last 30 years of the fifteenth century, 15 editions in Latin and one in Hebrew were made of *al-Qanun*.[140] During the sixteenth century it was issued more than 20 times. From the twelfth century to the seventeenth century it was the "chief guide to medical science in the West,"[141] and it has remained "a medical bible for a longer period than any other work."[142]

Ibn Sina was the first to describe meningitis and differentiate it from meningismus of other acute diseases and to suggest treatment for lachrymal fistula, the first to describe the manner of spread of epidemics and the contagious nature of tuberculosis.[143] Ibn Sina described details of the eye, including: conjunctive sclera, cornea, choroids, iris, retina, layer lens, aqueous humour, optic nerve and optic chiasm.[144] Other important medical figures included: Ibn Zuhr (Avenzoar, d.1161) for his work on diet, Ibn Rushd (Averroes, 1121-1198) for his work on general principles, and the Syrian Ibn al-Nafis (d.1288) for his discovery of the

[136] Hitti, *op. cit*., p.111
[137] Nasr, *Islamic science: An Illustrated Study*. *op. cit*., pp.178-179
[138] Sarton, *op. cit*., p.710.
[139] Turner, *op.cit*., p.136.
[140] Hitti, *op. cit*., p.110.
[141] *Ibid*, p.111.
[142] *Ibid*.
[143] Nasr, *Islamic science: An Illustrated Study, op. cit*., p.179.
[144] *Ibid.*

minor circulation of the blood.

SUMMARY AND CONCLUSION

The aim of this chapter has been to show that a huge and brilliant entity, the Islamic Empire, did a great deal of science. The chapter has demonstrated, albeit briefly, that recent significant mass of excellent studies by competent historians has led to a qualitative shift in our understanding of the importance, originality and profound influence of Islamic science. In this context, it is important to understand that Islamic science is not independent of ancient science; however, genuine science was done, it predated similar discoveries in the West, and it also impacted upon the Renaissance. The cases of mathematics, astronomy and medicine in Islam have demonstrated this point. In mathematics, many of the ideas, which were thought to belong to European mathematicians of the sixteenth, seventeenth, and eighteenth centuries, are now recognised to have originated by Islamic mathematicians. Medieval Islamic astronomers were not mere translators but also may have played a key role in the Copernican revolution, which ultimately influenced the Renaissance. And the originality of Islamic medicine does not lay in the mass of information that it conveyed to the West via Arabic translations, but in the way it helped medicine to become established as a science.

Since it is now clear that much genuine and important science was done in the Islamic Empire, it is equally clear that the fate of this scientific enterprise merits scholarly study. Logically, therefore, the scholarly community should be devoting some of its resources to elucidating this important topic. What would we expect of a scholarly community? In the next chapter, the dissertation will examine the key characteristics of a scholarly community, before going on to examine what scholarship actually exists regarding the fate of Islamic science.

3

THE SCHOLARLY COMMUNITY: IDEAL STANDARDS AND CONSTRICTING PROBLEMS

INTRODUCTION

Chapter Two has demonstrated that the Islamic empire did a great deal of genuine high quality science, which continued well into the nineteenth century.[1] Since the fate of Islamic science is clearly worthy of scholarly study, it is reasonable to inquire what would characterise a community, which undertook such a study. The aim of this chapter, therefore, is to examine the nature of an ideal scholarly community, and the qualitative standards that it needs for, and the constricting problems that may hinder, the production of reliable knowledge. This chapter sketches a rough outline of an ideal scholarly community; not in a comprehensive spirit, but in the way some scholars define it. This account owes much to that presented by Ernest Boyer who wrote extensively on scholarship. The point of this chapter is *not* to develop a new set of qualitative standards of a scholarly community, nor a new set of qualities of a scholar, but to utilise a certain conception of it in order to bring out more clearly why these standards are needed to measure adequacy of scholarship.

[1] Jan P. Hogendijk and Abdelhamid Sabra (eds), *The Enterprise of Science in Islam: New Perspectives* (Cambridge: The MIT Press, 2003), p.vii.

A number of approaches can be used to evaluate scholarship, including the positivist, relativist, Marxist (elitist), or post-modernist (pluralistic). The positivist approach claims that valid knowledge (scientific truths) would be found through a process of correction and adjustment.[2] That truth is the result of an asymptotic progress towards an ultimate or definitive knowledge. One of the underlying assumptions of this approach is that theories and hypotheses would be put forward and evidence would be generated to support, reject, or modify those claims.[3] Through a built-in method of correction (replication), the result would be "a uniquely high quality of knowledge."[4] This knowledge is explicitly contrasted with other types of knowledge that are not based on source or validity. Different scholars, Comte among others, argued this case, and this position was termed positivism.[5] This approach is "sometimes opposed to realism, particularly in the interpretation of the nature of the unobservable theoretical entities that occur in scientific discourses."[6] This approach is criticised by proponents of the relativist approach.

The relativist approach states that there is no objective reality: all knowledge is a social construction.[7] The production of empirically supported knowledge is "no more than "agreements" imposed by the positivists who control the major academic institutions and the leading scholarly publications."[8] This approach

[2] Richard F. Hamilton, *The social Misconstruction of reality: Validity and Verification in the Scholarly Community* (New Haven: Yale University Press, c1996), p.3.
[3] *Ibid.*
[4] *Ibid.*
[5] *Ibid.*
[6] Alan Bullock and Oliver Stallybrass, *The Fontana Dictionary Of Modern Thought* (London: Collins, 1977), p.486.
[7] Hamilton, *op.cit.,* p.4.
[8] *Ibid.*

claims that knowledge does not have a binding character, but is arbitrary and all claims are equally valid.[9]

The Marxist or elitist version of the social construction position,[10] argues that scholarship serves the interest of the ruling class, and in the case of the West, that means the capitalist. This course would emphasis the qualities of Western science and Western society. The later Marxists Antonio Gramsci, Louis Althusser, Nicos Poulantzas and members of the Frankfurt school of sociology, most notably Herbert Marcuse, have been proponents of this view.[11]

The postmodernist approach adopts "a systematic scepticism of grounded theoretical perspective."[12] The concentration of this approach is "on the tensions of difference and similarity erupting from these globalisation processes: circulation via people, cross-cultural interaction, interaction of local and global knowledge."[13] Accordingly, postmodernists are apprehensive of "authoritative definitions and singular narratives of any trajectory of events."[14] Their attacks on ethnography are based on the belief that there is no true objectivity. Scientific method is not possible.[15] Hence, a post-modernist (or pluralistic approach)[16] would argue that there are many different accounts of the fate of Islamic science, and that no one is 'the' account of what happened. Therefore, it would be accepted that there are different accounts, and (from Foucault's perspective) it

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[9] *Ibid.*
[10] *Ibid.*
[11] *Ibid.*
[12] Shannon Weiss and Karla Wesley, 'Postmodernism and Its Critics,' *Department of Anthropology College of Arts and Sciences*, The University of Alabama. http://www.as.ua.edu/ant/Faculty/murphy/436/pomo.htm. (21/6/2003).
[13] *Ibid.*
[14] *Ibid.*
[15] *Ibid.*
[16] Hamilton, *op.cit.,* p.4.

might be asked why one particular approach became predominant in the West, as opposed to others.

The conception that will be adopted in this thesis is widely recognised, and yields some fairly straightforward criteria, which makes it possible to examine whether a functioning community exists that could investigate what happened to Islamic science. The key point is that the approach used here is a normative one: what should be the case rather than what actually is? What factors would facilitate (or hinder) the production of valid knowledge in a scholarly community?

This chapter is organised in the following manner. Section one defines what is a "community." It considers, in a preliminary way, the important elements that constitute a "community." The aim is not to cover every element, but to highlight the most important. Section two defines a scholarly community in the light of the definition of "community" given in section two. The aim is to highlight the distinguishing characteristics of an ideal scholarly community. Section three examines the different types of scholarship, highlighting the most important types of scholarship. Section four outlines the standards of scholarly work, emphasising that qualitative standards offer a powerful conceptual framework to guide evaluation of scholarship. Section five examines the qualities of a scholar, who is at the heart of a scholarly community and scholarship. It considers, in a preliminary way, the various qualities a scholar needs to possess in order to produce reliable knowledge. The aim is not to cover every quality of an ideal scholar, but to stress some of the most important ones. Section six aims at highlighting some of the constricting problems that may hinder the production of adequate knowledge. Finally, section seven gives a practical example from the writing of the history of Islamic astronomy, which highlights some of the implications of inadequate scholarship.

1. WHAT IS A COMMUNITY?

Traditionally, sociologists and anthropologists have characterised communities based on geographical or physical nearness.[17] However, the combined impact of "industrialization, urbanization, and modern transportation and communication systems has diminished the usefulness of proximity in delimiting the boundaries of communities in the twentieth century."[18] Accordingly, sociologists and anthropologists have been forced to either abandon the concept of community in the study of modern society, or re-examine their understanding of the social characteristics that are essential to the structure of community.[19]

Therefore, new definitions of communities have emerged, where communities are defined as: "collectivities of like-minded individuals formed when a group of people comes to think in roughly the same way, sharing foundational beliefs, and agreeing on important issues."[20] Cohen remarks, "most of the social collectivities we would regard as communities are characterised by deep and enduring disagreements over fundamental issues."[21] Thus he suggests "that what constitutes community is not a shared set of beliefs but is rather a common symbolic system comprised of a shared set of symbols, constructs, and norms for communication

[17] Teresa M. Harrison and Timothy D. Stephen, *The electronic journal as the heart of an online scholarly community,* (Networked Scholarly Publishing) *Library Trends*, 43, 3, Spring 1995, p.592 (17).
[18] *Ibid.*
[19] *Ibid.*
[20] *Ibid.*
[21] A. P. Cohen, *The Symbolic Construction of Community* (London: Tavistock Publications, 1985).

through which the routine discourse activities of a people takes place."[22] He also argues that:

> It is the community itself and everything within it, its conceptual as well as material, has a symbolic dimension, and, further, that this dimension does not exist as some kind of consensus of sentiment. Rather, it exists as something for people 'to think with.' The symbols of community are mental constructs: they provide people with the means to make meaning. In so doing, they also provide them with the means to express the particular meanings, which the community has for them. [23]

Communicating via mutually understood terms is significant, because some would argue that knowledge is transmitted through the use of agreed-upon symbols.[24] It is important to also note that the "choice of symbols, or terms of analysis, from among the available conceptual options predetermines the results, that is, how we will perceive, know, and understand 'reality.'"[25]

Accordingly, a community is a group of people who share "commonality of forms"[26] and not a "tract of physical space or uniformity in the meanings of relevant phenomena."[27] Therefore, community can be defined by ethnicity,

[22] *Ibid*, p.19.
[23] *Ibid.*
[24] Harrison *et al*, *op.cit.,* p.4.
[25] *Ibid.*
[26] *Ibid.*, p.2.
[27] *Ibid.*

professional, organizational affiliations, or by "deep and compelling interests in particular subject matters, as for example, scholarly communities."[28]

2. Adequate Communication: A Vital Characteristic Of A Scholarly Community

Scholarly communities might be described as "discourse communities."[29] A discourse community "focuses attention on the particular conventions for written communication that characterise a group of individuals."[30] More precisely, a discourse community - or a scholarly community - is a specialised group, such as an academic discipline, with members who "know what is worth communicating, how it can be communicated, what other members of the community are likely to know and believe to be true about certain subjects, how other members can be persuaded, and so on."[31]

Discourse communities, or scholarly communities, have "special ways of knowing, believing, and persuading."[32] Experienced writers within a scholarly community are able to draw upon each other for knowledge "about what will count as appropriate language, appropriate evidence, and appropriate reasoning."[33] In other words, members of scholarly communities understand how to communicate with each other.[34] Failure to communicate adequately eventually leads to failure in the production of reliable new knowledge. That is why the

[28] *Ibid.*
[29] *Ibid.*
[30] *Ibid.*
[31] *Ibid.*
[32] Harrison *et al, op.cit.* p.2.
[33] *Ibid.*
[34] *Ibid.*

usefulness (success or failure) of a scholarly community's "written products is evaluated according to standards or criteria that are, at least in part, distinctive."[35]

Members of a scholarly community are bound together by the key link of communication of information and knowledge.[36] Since this means of bonding is vital to the production of reliable new knowledge, then any inadequacies therein will lead to inadequacies in the validity of new knowledge. Communication can vary in form, of course, but communication by the printed word is important for a scholarly community for a number of reasons: The preservation of results, theories, observation, for the later reference by other scholars; and for providing opportunities for criticism, refutation and further refinement of the supposed facts.[37]

Thus, in a scholarly community, communication of the results of research is important because it allows any body of knowledge to be corrected and clarified by mutual criticism.[38] Such a process can be described as a "corporate activity" in which scholars build upon the work of predecessors, in competitive collaboration with other contemporaries.[39] Communication is, therefore, an essential foundation of scholarship. If ideas are not communicated to other scholars, and tested within the scholarly community, then the quality of scholarship cannot be guaranteed.[40]

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[35] *Ibid.*
[36] John Ziman, *The Force of Knowledge The Scientific Dimension of Society* (Cambridge: Cambridge University Press, 1976), p.90.
[37] *Ibid.*
[38] *Ibid.*
[39] *Ibid.*
[40] Ylva Lindholm-Romantschuk, *Scholarly Book Reviewing in the Social Sciences and Humanities* (London: Greenwood Press, 1998), p.7.

3. IDEAL SCHOLARSHIP: DEFINITION AND CATEGORISATION

In his definition of scholarship, Ernest Boyer adduced that scholarship can be thought of as having four separate, but overlapping, functions. These are: the scholarship of discovery (research); the scholarship of integration (synthesis); the scholarship of application/engagement (practice); and the scholarship of teaching (learning).[41] Other definitions of scholarship are also applicable. Wise, for example, defines scholarship as "creative, intellectual work," or "added to our intellectual history through its communications."[42] Others define it as, "breaks new grounds and is innovative," or "can be replicated or elaborated…can be documented," or "has significant impact."[43] All of these definitions are significant, but this chapter shall only briefly discuss Boyer's categorisation of scholarship.

SCHOLARSHIP OF RESEARCH OR DISCOVERY

The scholarship of research constitutes one of the most fundamental characteristics of scholarly work. It contributes to the stock of human knowledge by enhancing freedom of inquiry, and the following of, in a disciplined manner, an investigation wherever it may lead.[44] This means that specific claims, arguments, and theories are not accepted on face value. Rather, in any given case, the scholarship of research must allow a scholar to question whether those

[41] Ernest L. Boyer, *Scholarship Reconsidered: Priorities of the Professoriate* (Princeton: The Carnegie Foundation for the advancement of teaching, 1990), p.16.
[42] Greg Wise, "Assessing the Scholarship of Engagement: Adapting Scholarship Reconsidered and Scholarship Assessed to Evaluate Outreach Faculty for Promotion and Tenure," *University of Wisconsin-Extension*, http://www1.uwex.edu/secretary/$WPM79FB/index.htm. (01/24/2002).
[43] Diamond in *Ibid.*
[44] Boyer, *op.cit.,* p.16.

specifics are accurate, valid, or proven.[45] In a scholarly community, if one is sceptical about a given theory, and if those doubts prove justified, that discovery should lead to a reconstruction, in other words, to a more suitable analysis of the case.[46] One of the assumptions underlying scholarship of discovery is that a systematic effort allows faulty theories based on mistaken assumptions, or unsustained predictions, to be either "repaired" or "abandoned."[47] In historical study, for example, a basic requirement is checking of original sources. The "aim is to review the primary evidence and the judgments drawn at the earliest steps in a sequence."[48]

The key task of discovery is to provide a better understanding of ideas.[49] Ideas constitute the raw material from which knowledge is produced.[50] Many ideas will have to be discarded somewhere in the process of producing authenticated knowledge.[51] Various kinds of ideas can be classified by their relationship to the authentication process.[52] At the heart of the authentication process is proper scholarly research – or discovery. There are ideas that are systematically prepared for authentication (theories).[53] Other ideas are not derived from any systematic process (visions).[54] Some ideas are unable to survive any reasonable authentication process (illusions).[55] Other ideas exempt themselves from any

[45]Hamilton, *op.cit*., p.xii.
[46] *Ibid.*
[47] *Ibid.*
[48] *Ibid.,* p.8.
[49] *Ibid.* p.xii.
[50] Thomas Sowell, *Knowledge and Decisions* (New York: Basic Books, 1980), pp. 4-5.
[51] *Ibid.*
[52] *Ibid.*
[53] *Ibid.*
[54] *Ibid.*
[55] *Ibid.*

authentication process (myths).[56] Finally, there are ideas that pass authentication processes (facts), and others that are known to have failed – or certain to fail – such processes (falsehoods – both mistakes and lies).[57] The important point here is that an ideal scholarship research "distinguishes such systematic authentication procedures from decisions based on consensus, emotions, or tradition."[58]

These various ideas are conceptually different, but a given notion may evolve through several of these states. For instance, a scholar may begin with a general notion of how and why certain things happen the way they do, without having any factual evidence or any logical structured arguments about it.[59] Then one may proceed to systematically determine (via research) whether this vision is correct, then certain empirical consequences will be observable under the proper conditions.[60] The 'vision' had led to a 'theory.' The proper conditions may be observed in history or otherwise constructed or discovered, and the validity and certainty of the results may be more or less open to criticism.

Scholarship of research attempts to simplify events using a set of statements that define and link them together. Those statements are generally known as theories, and are meant to illustrate what is important, and how these important events are casually connected. Most theories, it should be noted, are derived out of different contributions of historical accounts, reports of contemporary events, and direct

[56] *Ibid.*
[57] *Ibid.*
[58] *Ibid.*
[59] *Ibid.*
[60] *Ibid.*

experience. [61] Most social theories involve two processes: one is intellectual, and one is social.[62]

One of the assumptions underlying the intellectual process is that it allows scholars to "know or understand a complex reality."[63] Generally, these intellectuals set out to simplify these complex realities by offering theories based on certain research or discoveries. But most intellectuals do not really offer theories; they use or disseminate such schemes. Few intellectuals actually develop and justify theories or simplified schemes to explain certain events.[64] Intellectuals who receive these theories apply them in subsequent research or they disseminate the basic elements of those theories to a wider audience.[65] The social process, on the other hand, involves people passing on and vouching for a given theory.[66] Together with others convinced of its merit, they use the scheme in subsequent research and analysis, and also pass it to others.[67]

In ideal scholarly research, then, scholars distinguish facts from decisions based on consensus, emotions, or traditions.[68] Systematic authentication involves a testing of the logical structure of a theory for internal consistencies and a testing of the theory's results for external consistency with the observable facts of the real world.[69] Consensual approval, on the other hand, is the approval of some special reference group in the past, present or future. Within such a group, ideas that lack

[61] Hamilton, *op.cit.,* p.198-99.
[62] *Ibid.*
[63] *Ibid.*
[64] *Ibid.*, p.199.
[65] *Ibid.*
[66] *Ibid.*
[67] *Ibid.*
[68] Sowell, *op.cit.*, p.4-5.
[69] *Ibid.*, p.5.

logical, empirical, or general consensual support may still be accepted as valid.[70] There are, therefore, two types of consensus: those reached after the appropriate scholarly processes, and those reached without applying them. Both are consensuses, but only the former is the product of true scholarship.

In both processes, theories based on research or consensual approval, there is the concern for "adequacy, for the realism, validity, or truth of the schemes in question."[71] The hope is that a theory will provide an accurate expression of that "complex reality." Scholarship of research should aim to achieve that by differentiating 'pure knowledge' from 'pure myth.' This authentication procedure attempts to link theories with actual evidence by means of research. The absence of, or inadequacies in, scholarship of research could lead to serious problems, some of which will be explained in section six.

At the heart of a scholarly research, of course, is the scholar. A scholar, who seeks to do proper scholarly research, must have read closely and be intimately familiar with a large number of particular works.[72] Thus, some scholars do background reading (textbooks), comprehensive reading (everything possible, which is or may be relevant), continual reading (simultaneous and associative), and they "read around" a period or a person.[73] They read books and related primary material closely - "for detail" and to become "immersed" in their area of inquiry.[74] Even

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[70] *Ibid.*
[71] *Ibid.*
[72] William S. Brockman, Laura Neumann, Carole L. Palmer and Tonyia J. Tidline, *Scholarly Work in the Humanities and the Evolving Information En*vironment (Council on Library and Information Resources (CLIR) and the Digital Library Federation (DLF), 2001), http://www.clir.org/pubs/reports/pub104/contents.html. (3/6/2002).
[73] *Ibid.*
[74] *Ibid.*

old library catalogues may be read since they may contain valuable information.[75] Primary materials, or original and not derived material, are also read and reread to learn them as well as possible and to be able to set them into context - historical, authorial, generic, or cultural.[76] In fact, a basic but important rule of scholarly practice is that whenever possible a scholar should go to original sources. A scholar who wants to write about, say the history of the development of a particular branch of science, should read everything that has ever been published about that branch of science, and must be able to integrate it.

SCHOLARSHIP OF INTEGRATION

Integration is equally important because it allows members of a scholarly community to make "connections within and between their disciplines, altering the context in which people view knowledge and offsetting the inclination to split knowledge into ever more esoteric bits and pieces."[77] Furthermore, integrative scholarship is vital because it "educates nonspecialists by giving meaning to isolated facts and putting them in perspective."[78] That is, integration helps "interpret, draw together, and bring new insight to bear on original research."[79] In short, the purpose of integration is interpretation and fitting results of research into a larger intellectual pattern.[80]

[75] *Ibid.*
[76] *Ibid.*
[77] Charles E. Glassick, Mary Taylor Huber, and Gene I. Maeroff, *Scholarship Assessed: Evaluation of the Professoriate* (San Francisco: Jossey-Bass Publishers, 1997), p.9.
[78] *Ibid.*
[79] *Ibid.*
[80] Boyer, *op.cit.*, p.19.

Moreover, there is a subtle, but serious, distinction between scholarship that seeks to "discover" and to "integrate." Scholars who seek to discover ask, "What is to be known, what is yet to be found?"[81] But scholars involved in integration ask, "What do the findings mean? Is it possible to interpret what's been discovered in ways that provide a larger, more comprehensive understanding?"[82] These type of questions, explains Boyer, if "carefully pursued can lead the scholar from information to knowledge and even, perhaps, to wisdom."[83] Otherwise, they can lead to a series of disparate, random, and overlapping undertakings.

Scholarships of Application and Teaching

The scholarships of research and integration reflect "the investigative and synthesising traditions"[84] of scholarship. The scholarship of application, on the other hand, is the scholarship of "engagement," in which a scholar asks, "How can knowledge be responsibly applied to consequential problems?"[85] Finally, the scholarship of teaching is where scholars act as teachers whose purpose is to create a common ground of intellectual commitment.[86]

The above types of scholarship are vital, and in order to recognise them as legitimate forms of scholarship, they need to be evaluated by a set of qualitative standards that "capture and acknowledge what they share as scholarly acts."[87]

[81] *Ibid.*
[82] *Ibid.*
[83] *Ibid.*
[84] *Ibid.*, p.21.
[85] *Ibid.*
[86] *Ibid.*, p.24.
[87] Glassick *et al*, *op.cit.*, p.22.

4. QUALITATIVE STANDARDS

Glassick *et al* explain that all works of scholarship involve a common set of qualitative standards: Clear goals; adequate preparation; appropriate methods; significant results, effective presentation and reflective critique.[88] Taken together, these qualitative standards offer a "powerful conceptual framework to guide evaluation of scholarship."[89] Explicit articulation of these will follow.

CLEAR GOALS

First and foremost, a scholar must be clear about his or her goals. In this regards a number of questions ought to be asked about all types of scholarly work:

- Does the scholar state the basic purposes of his or her work clearly?
- Does the scholar define objectives that are realistic and achievable?
- Does the scholar identify important questions in the field?[90]

Clear goals are important because a scholar must know what questions to ask. Since scholarly work entails multiple goals, it is crucial that the scholar define each goal clearly within relevant contexts.[91] Only by doing this can the phase be set for conversations about suitability of goals.[92] Clear goals allow adequate guiding questions that help the scholar define "a project, give it structure,

[88] *Ibid*., p.24.
[89] *Ibid*., p.25.
[90] *Ibid*.
[91] *Ibid*., p.26.
[92] *Ibid*.

recognise relevant material, identify exceptions, and see new possibilities."[93] Scholarly goals must be realistic, practical and defensible, also.[94]

ADEQUATE PREPARATION

One of the most basic aspects of scholarly work is adequate preparation. Therefore, any evaluation of scholarship's achievements should consider the following questions:

- Does the scholar show an understanding of existing scholarship in the field?
- Does the scholar bring the necessary skills to his or her work?
- Does the scholar bring together the resources necessary to move the project forward?[95]

Scholars are also responsible for keeping up with the literature in the field of their work.[96] Adequate preparation is vital in this regard, because scholarship is communicated by knowing what is being discussed and what others have said on the subject.[97] Consequently, a scholarly work that does not address "current issues of theory, fact, interpretations, or method is unlikely to contribute to its field, regardless of other virtues."[98] Adequate preparations also entail that a scholar

[93] *Ibid*.
[94] *Ibid*.
[95] *Ibid*., p.27.
[96] *Ibid*.
[97] *Ibid*.
[98] *Ibid*.

should "ascertain the availability of the right resources for the project at hand."[99] In doing so, a scholar should "know who is doing similar work, who is supporting such work, and who is interested in the findings."[100] A particular scholarly work might demand the learning of a new language,[101] or exploring primary text in their original language and not merely depend on translations.

Furthermore, the success or failure of a scholarship depends on resources, and questions about resources are important for evaluating adequacy of preparation.[102] Question that might be asked for such evaluation include: Was the scholar imaginative and thorough in finding source material? Were the resources adequate for the project? Did the scholar use the resources as well as possible?[103]

Appropriate Methods

A scholar must also use appropriate methods for the project, choosing them wisely, applying them effectively, and modifying them cautiously as the project evolves.[104] In evaluating appropriateness of methods, the following questions need to be asked:

- Does the scholar use methods appropriate to the goals
- Does the scholar apply effectively the methods selected?

[99] *Ibid*.
[100] *Ibid*.
[101] *Ibid*.
[102] *Ibid*.
[103] *Ibid*.
[104] *Ibid*.

- Does the scholar modify procedures in response to changing circumstances?[105]

Appropriate methodology gives a scholarly work "integrity and engenders confidence in its findings, product, or results."[106] According to Edward Shils, the obligations of scholarship are "inherent in the custodianship of the pursuit, acquisition, assessment, and transmission of knowledge through systematic study, in accordance with methodological procedure including observational techniques, rules of evidence, and principles of logical reasoning."[107] Though scholars may differ on methodology, however, what is imperative is that the method selected be vigilantly justified and appropriate to the project's goals.[108]

SIGNIFICANT RESULTS

Significance of results must also be used to evaluate scholarship. A scholarly project should "contribute to knowledge."[109] The significance of results of scholarship can be evaluated by asking the following questions:

- Does the scholar achieve goals?
- Does the scholar's work add consequentially to the field?
- Do the scholar's work open additional areas for further exploration?

[105] *Ibid*.
[106] *Ibid*., p.28.
[107] Edward Shils, *The Academic Ethic* (Chicago: University of Chicago Press, 1984), p.10 cited in *Ibid*.
[108] Glassick, *et al*, *op.cit*., p.29.
[109] *Ibid.*

Of importance is that the results of a scholarly work should satisfy the goals that the scholar has set for the project.[110] Furthermore, the significance of a scholarly work is judged according to its contribution to the field, including opening new areas for further expansion, and originality that may increase the potential for breaking new grounds.[111]

Effective Presentation

Adequate communication of information depends on effective and suitable presentation. Without this, discoveries remain known only to the scholar and perhaps a small circle of other individuals. In short, scholars must communicate well.[112] Thus, in reviewing a scholar's work, the following questions ought to be asked about presentation:

- Does the scholar use a suitable style and effective organisation to present his or her work?
- Does the scholar use appropriate forums for communicating work to its intended audience?
- Does the scholar present his or her message with clarity and integrity?[113]

Whatever medium of communication the scholar chooses to communicate his or her results, it is important that all scholarly work containing "evidence, analysis, interpretation, and argument," should be handled carefully and honestly.[114]

[110] *Ibid.*, p.30.
[111] *Ibid.*
[112] *Ibid.*, p.32.
[113] *Ibid.*

REFLECTIVE CRITIQUE

As a last standard, reflective critique requires that the scholar thinks of his or her work, seeks opinions of others, and learns from this process so that scholarship can be improved.[115] The following questions should be asked when evaluating this standard:

- Does the scholar critically evaluate his or her work?
- Does the scholar bring an appropriate breadth of evidence to his or her critique?
- Does the scholar use evaluation to improve the quality of future work?

Reflective critique allows a scholar to examine his or her work from various perspectives. Reflection, in turn, leads to creativity that enables the scholar to "invent, devise, envisage and improvise,"[116] and not merely repeat what others have said. According to Ernest Lynton, creativity is not only essential, but also the defining, characteristic of scholarship.[117] Reflective critique, then, allows careful evaluation and constructive criticism, both of which "enrich scholarly work by enabling old projects to inform new ones."[118] Reflection encouraged by these activities, consequently, "connects separate scholarly works and makes them integral parts of some larger Intellectual quest."[119] Thus, as the scholar moves on

[114] *Ibid.*, p.33.
[115] *Ibid.*
[116] *Ibid.*, p.34.
[117] Ernest A. Lynton, *Making the Case for Professional Service* (Washington, D.C.: American Association for Higher Education, 1995), p.25.
[118] Glassick *et al*, *op.cit.*, p.35.
[119] *Ibid.*

with his research, older scholarly works feed ideas to the new ones, and the new ones enrich and add to the old ones.[120]

5. Some Ideal Qualities of a Scholar

Certain qualities are consequential for the individual scholar and the entire scholarly community. This section examines the qualities of a scholar that facilitate the production of empirically supported knowledge. The aim is to highlight some, not all, of the most important qualities.

In his article "The Scholar in Society," Wayne Booth has proposed that a scholar must have what is called "habits of rationality."[121] These include courage, persistence, consideration, humility, and honesty.[122] Booth argues that these qualities are important because they shape the "scholar's intellectual work and knowledge."[123] Furthermore, Booth suggests that the "public role of the scholar is to serve as an exemplar of these qualities in society, to testify to the value of "shared reason" in public debate." [124]

Others, like Sir Eric Ashby, suggest that scholars have "an inner integrity." Hence, he suggests that a code needs to be implemented that "would not permit the scholar to hide some facts nor to consider race or religion or political party in

[120] *Ibid.*
[121] Wayne C. Booth, *The Vocation of a Teacher: Rhetorical Occasions 1967-1988* (Chicago: University of Chicago Press, 1988), pp. 67-75.
[122] *Ibid.*
[123] *Ibid.*
[124] *Ibid.*

assessing scholarship."[125] Ashby suggests that the code would further demand that a scholar shows "tolerance for other points of view and encourage both consent and dissent in debate."[126] The absence of these important qualities would render the scholarship bigoted and biased.

A leading quality that scholars must possess is integrity. Integrity entails "truthfulness, fairness in dealing, and absence of fraud, deceit, and dissembling."[127] Integrity also requires "an awareness of one's own bias and readiness to follow sound method and analysis wherever they may lead."[128] Integrity also entails that scholars must be honest in reporting what they have done and found.[129] A scholar's claims about any type of research must be true, and not manufactured or modified.[130] Integrity also entails that a scholar does not present unsubstantiated opinion as established truth."[131] Doing so, according to Shils, is as unethical as knowingly putting forward "a false proposition as true…"[132]

One of the hallmarks of integrity is objectivity. Objectivity demands that a scholar is "free from personal feelings or bias."[133] Or it can also imply "expressing or dealing with facts or conditions as perceived without distortion by personal

[125] Eric Ashby, "A Hippocratic Oath for the Academic Profession," *Minerva*, 7, 1-2, 1968-69, pp.64-66.
[126] *Ibid.*
[127] *The American Heritage Dictionary*, 2nd College Edition, s.v. "Honesty," cited in Glassick *et al*, *op.cit*., p.63.
[128] American Historical Association, *Statements on Standards of Professional Conduct* (Washington, D.C.: author, 1993), p.1.
[129] Glassick *et al*, *op.cit*., p.63.
[130] *Ibid.*
[131] *Ibid.*., p.64.
[132] Shils, *op.cit.,* p.42.
[133] Blair D., *The Pocket Macquarie Dictionary* (QLD: The Jacaranda Press, 1982), p.619.

feelings, prejudices, or interpretations."[134] Another requisite of integrity is fairness.[135] Fairness is marked by impartiality and honesty: free from self-interest, prejudice, or favouritism.[136] Objectivity and fairness are particularly important in scholarship that deals with a foreign historical cultural heritage, scientific or otherwise. An objective and fair scholar would study historical text of other cultures free of bias, and without viewing such cultures as "others." The absence of this, however, could hinder the production of empirically supported knowledge, as shall be explained in the next section.

Sections three and four demonstrate that scholarship needs to follow a common set of qualitative standards, and a scholar needs to possess certain qualities, in order to produce empirically supported knowledge. A scholarly work that lacks some, or all, of these standards and qualities is unlikely to contribute to its field, regardless of other virtues. Departure from these standards and qualities could lead to misrepresentation, and serious blunders, affecting not only interpretation but comprehension too. In the real world of scholarship, such departures occur due to a number of constricting factors.

6. CONSTRICTING FACTORS: BEYOND THE IDEAL SCHOLARSHIP

Scholarly activity does not always follow the path of ideal standards, and scholars are not always 'guided' by ideal qualities. The underlying ideal standards for measurements of scholarly work can be unrealistic in the real world. Most

[134] *The Merriam-Webster Dictionary On Line*. http://www.m-w.com/cgi-bin/dictionary
[135] Glassick *et al*, *op.cit*., p.64.
[136] *The Merriam-Webster Dictionary* On Line, *op.cit.*

knowledge is transmitted through social networks, and therefore, is subject to interpersonal factors that can hinder the production of knowledge.

According to Hamilton, the production of knowledge can be hindered due to social psychological components, procedural problems, or both.[137] Social psychological factors can include: A trained concern with the "inner logic" of a paradigm; an unreasoning preference for given viewpoints; conformity or the acceptance of viewpoints regardless of evidence; the failure of gatekeepers in directing the flow of information; the development of permissive standards for judgment.[138] Procedural problems can include failure to check text claims against original sources;[139] and understanding, comparison and translation of text that belong to a different culture.[140] Constricting factors can operate individually, or they can very much be interconnected.

A TRAINED CONCERN WITH THE "INNER LOGIC" OF A PARADIGM

It was already said that the main objective of research is to verify specific claims, arguments, and theories. In other words, scholars must not accept claims on face value. In any given case, a scholar must question the accuracy of initial assumptions, and must attempt to discover - via research - empirical support for claims. The direction of research or discovery can be constrained if, for instance, a scholar fails to question the realism of initial assumptions.

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[137] Hamilton, *op.cit.*, p.201.
[138]*Ibid*
[139] *Ibid.*, p.205.
[140] Bryan S. Turner, *Orientalism, Postmodernism & Globalism* (New York: Routledge, 1994), p20.

That is, there is always a possibility that scholars may attempt to work out the "inner logic" of a set of initial assumptions with high surface probability, and not the realism of the first principles themselves.[141] For example, if one considers the case of scholarship regarding the fate of Islamic science, some researchers might be concerned with the implications of a decline theory (causal factors) and not the realism of the initial assumption of decline. While this approach may lead to some valuable and useful work, it may possibly take centuries before it can be recognised that the basic assumptions are themselves problematic. Therefore, a trained concern with the 'inner logic' of a hypothesis can constrain the direction of research efforts.

AN UNREASONING PREFERENCE FOR GIVEN VIEWPOINTS

Loyalty, or a trained attachment, is a psychological factor that makes scholars (and other people) develop "attachment to some preferred paradigm assumptions and are reluctant to see, hear, or accept contrary evidence.[142] That is, some scholars may become so attached to certain notions that they ignore or "reject findings seen as detrimental to their cause."[143] A striking example can be also drawn from the history of Islamic astronomy. The previous chapter highlighted the influence that Ibn Shatir's manuscript must have had on that of Copernicus. Saliba explains that in 1957, two scholars presented for the first time Ibn al-Shatir's archaic manuscript to a group of historians. But because these historians believed in the originality of Copernicus', the manuscript was "greeted with

[141] Hamilton, *op.cit.*, 205.
[142] *Ibid*.
[143] *Ibid.*

responses that ranged from total disbelief to total denial."[144] In other instances, "some historians even walked out of public lectures when the manuscript was mentioned."[145] This may be due to unreasoning preference to a given viewpoint.

CONFORMITY TO, OR THE ACCEPTANCE OF, VIEWPOINTS REGARDLESS OF EVIDENCE

People who are conformists will go along with almost any social environment, as Stanley Milgram's obedience experiment demonstrated.[146] Milgram conducted a controversial study the results of which told us something about ourselves that we would rather ignore.[147] Most people believe that they make up their minds about how to behave, and reject the notion that we are submissive, willing to give up our judgments so easily. Milgram's study, however, showed that most of us (including intellectuals) could be conformists to those in authority.[148]

Intellectuals who are conformists will find it difficult to challenge a consensus. Like other human beings, intellectuals would feel "discomfort, stress, or even some degree of angst at the thought of going against an established consensus or against 'authority.'"[149] Given the conformist tendencies, it is possible that proponents of new and challenging findings would face some difficulties in receiving a hearing for their challenging views.[150] This psychological factor

[144] George Saliba, "Greek Astronomy and the Medieval Arabic Tradition," *American Scientist*, 90, 2002 July-August, p.360.
[145] *Ibid.*
[146] M. Bridgstock, David Burch, John Forge, John Laurent and Ian Lowe, *Science, Technology and Society: An Introduction* (Cambridge: Cambridge University Press, 1998), p.66-69.
[147] *Ibid.,* p.67-8.
[148] *Ibid*
[149] Hamilton, *op.cit*, p.203.
[150] *Ibid*., p.204.

would restrain scholars both in the choice of research topics and in the presentation of findings.[151]

THE DEVELOPMENT OF PERMISSIVE STANDARDS FOR JUDGMENT

In cross-cultural studies there is a danger that scholars may operate according to set of standards by which they evaluate their own culture, and another altogether different, less exacting one, which is applied to other cultures and civilisations. The scholarly tradition known as 'Orientalism' is a good example of this. Orientalism is scholarship that basically portrays Europe as an area of superior culture and the Orient, in comparison, as an area of patently inferior culture, waiting to be manipulated and controlled.[152] With this attitude, Orientalist scholars served primarily to shape Europe's sense of identity rather than to explore or discover the Orient's.[153] Reproduced again and again, this accumulating Eurocentric knowledge passed into the West's collective memory bank, where it proceeded to colour the West's perceptions of the Islamic world (also China) and all it stood for, creating the 'Other' and establishing a 'them' and us' dichotomy.[154]

Sardar elaborates that Orientalism is concerned with the study of the Orient, "identifying, editing and interpreting the fundamental texts of these civilisations from one generation to another through an established chain of teachers and

[151] *Ibid.,* p.203.
[152] R. Springborg, "Multiculturalism and Orientalism: The role of values in academic study of the Middle-East," *Asian Studies Review*, 15, 2, 1991, pp.1-7.
[153] *Ibid.*
[154] *Ibid.*

students."[155] This scholarship studies other civilisations with "European ideas of God, man, nature, society, science and history and consistently found non-Western cultures and civilisations to be inferior and backward."[156] Furthermore, "it approached the Orient with specific notions of cultural history, the origins and development of religion, the ways in which sacred texts should be understood and interpreted, political ideas and how human societies evolve and develop."[157] While not all Orientalists fall in this categorisation, Hourani points out that this type of knowledge served as an indicator of the thought a particular age produced – namely, the imperialist age, which in its overt Victorian form has clearly passed into history.[158]

Edward Said also argues that the contents of the knowledge of Orientalism essentially misrepresented the Orient, particularly Islam and Muslim cultures.[159] Said further argues that, throughout the nineteenth and twentieth centuries especially, but to a degree going back to classical times as well, Western scholars effectively represented the Orient as mysterious, unchanging, despotic, backward – in essence uncivilised and alien.[160] Over time, what they produced was not an empirically supported knowledge, but an imperialist discourse – Orientalism – a cumulative way of thinking about the Orient and acting toward it.[161]

In the case of Islam, the Orientalist's notion defines the history of Islam with the "dominant theme of historical decay, retreat and decadence, because of which the

[155] Z. Sardar, *Orientalism* (Buckingham: Open University Press, 1999), p. p.4.
[156] *Ibid.*
[157] *Ibid.*,p.5.
[158] A. Hourani, *Islam in European Thought* (Cambridge: Cambridge University Press, 1991), p.38, and pp.57-8.
[159] Edward Said, *Orientalism* (London: Routledge and Kegan Paul, 1978).
[160] *Ibid.*
[161] *Ibid.*

explosive rise of Islamic society was followed by an equally rapid and total decline."[162] The consequence of this notion is that Islam, "is a religion which either fails to fulfil some latent promise or which represents some retardation of the prophetic monotheism in its sociological version, the Abrahamic faith."[163]

Permissive standards of judgment, therefore, raise serious questions about the nature of knowledge, its creation and dissemination. Can a true representation of anything be achieved? The *Journal of Asian Studies* pointed out in 1980, and again in 1991 that, it is never easy to "establish and transmit understanding across boundaries of languages, geography, culture and time."[164] While these problems are critical issues in most scholarly fields, they are of acute nature in cross-cultural studies. The problem with cross-cultural scholarship is, "in addition to the technical difficulties of bias, distortion and misrepresentation in the methodology," there are the "more profound questions of relativism, ethnocentrism and ideology, which call into question the whole basis of comparative analysis."[165]

The danger is that cross-cultural scholars may end up having "one set of standards by which they evaluate their own culture, and another altogether different, less exacting one, [166] which is applied to 'others'. This 'cultural relativism' does have

[162] Turner, *op.cit.,* p. 67
[163] *Ibid.*
[164] See, 'Review Symposium: Edward Said's Orientalism,' and "Introduction" to Forum on Universalism and Relativism in South Asian Studies,' *Journal of Asian Studies*, xxxix, 3, 1980, pp.481-517; L, 1, 1991, pp.29-34.
[165] Turner, *op.cit.,* p.20.
[166] *Ibid.*

a down side, and so scholars need to examine the values and beliefs which they bring to bear on their subjects,[167] lest they fall in the trap of 'us' and 'them.'[168]

INADEQUATE SCHOLARSHIP OF RESEARCH: FAILURE TO CHECK OR UNDERSTAND ORIGINAL SOURCES

It was said that one of the assumptions underlying scholarship of research is that through systematic effort information is assessed and errors are corrected. It was also said that in historical study a basic requirement is checking of original sources. However, variations may occur in those assessments, ranging from none to considerable. If the review is not adequate, distortion of proper understandings is likely to creep in and continue.[169] This inadequacy could lead to what Hamilton calls "inertial errors."[170]

Ideally, as a basic scholarly practice, researchers are supposed to check original sources before they ascertain any hypothesis. According to Hamilton, however, "one of the most fundamental of the procedural problems in scholarship is the failure to check claims against original sources."[171] Failure to check original sources means that scholars accept the following assumptions on faith, trust or acceptance: that original evidence actually exists; that the evidence is credible, without problem or difficulty; and that it has been accurately reproduced in all subsequent tellings.[172]

[167] *Ibid.*
[168] *Ibid.*
[169] Hamilton, *op.cit,,* p.8.
[170] *Ibid*
[171] *Ibid.,* p.205.
[172]*Ibid,*, p.17.

Failure to check original sources could lead to the uncritical acceptance of prior scholarly works. This could be either innocent (as with random error) or in some way "motivated," that is to say, the production of some predisposition.[173] Conclusions may be accepted "on faith" because of their surface plausibility, there being no immediate grounds for doubt. Alternatively, they may be accepted because they agree with prior training or preference.[174]

The failure to check original sources can be due to a number of factors. The first basic reason is that scholars may view certain claims as adequate, or worse, as worthy exemplary achievements when close examination would have revealed their inadequacy. Second, there is the simple fact that scholars may not have access to original sources. Third, scholars may have access to original sources but may not understand the language. In any case, there is a serious danger that scholars encountering any of these are likely to produce inadequate knowledge.

Systematic authentication by means of scholarly research can produce pure knowledge. Scholarship based on faith, and devoid of facts, is likely to produce pure myth. The crucial distinction in a scholarly work, therefore, is one of procedure, not of end result.[175] There is a fine distinction to be made here. Both genuine scholarship of research and consensual approval may look the same. However, one comes from a process of research, criticism and debate, the other simply from accepting pre-existing ideas.

[173] *Ibid.*, p.25.
[174] *Ibid.*
[175] Sowell, *op.cit.*, p.4-5.

INADEQUATE COMMUNICATION

The importance of adequate communication in a scholarly community was already explained in section two. It was said that communication is a vital characteristic for the production of adequate knowledge. It was also said that in an ideal scholarly community scholars understand how to communicate with each other via mutually understood terms.

It is important to note that inadequate communication could make the product of a scholarly community "a series of disparate, random, and overlapping undertakings."[176] Without adequate communication between members of a scholarly community, disciplines like science and history of science would not evolve in the way they are supposed to, and the social system of such disciplines would be seriously harmed.[177] This can also be true with regards to any scholarly discipline or community. If the goal of a scholarly community is the extension of certified knowledge, then this can be achieved only by "communicating the new knowledge through some commonly agreed upon venues,"[178] and mutually understood symbols. If this communication is not achieved, or is lacking in substance, then new knowledge cannot be extended.

PRESSURE TO PUBLISH

Another important constricting problem for the production of adequate scholarly work is pressure to publish. Pressure on scholars to publish research papers in

[176] Lindholm-Romantschuk*, op.cit.*, p.8.
[177] *Ibid.*, p.9.
[178] *Ibid.*

great quantity can be relentless. More papers mean more prestige for a researcher and their organisations. Unfortunately, this pressure is likely to prompt disreputable, unethical, and even fraudulent scholarly work.[179] At the very least, the pressure encourages scholars to ignore adequate research, especially of original material.

Of course, there are those who may equate quantity of scholarly publication with quality of scholarly achievement. But in reality “an increase in the number of publications per author actually can be attributed not so much to greater productivity, but to changes in the way researchers publish.”[180] Encouragement to publish may have its advantages, for example, researchers may undertake additional projects in order to generate significant new publications.[181] The trouble with pressure to publish is that it can increase the number of papers published without increasing the research output. This can be achieved in different ways - and they are all more or less disreputable.[182] In addition, pressure has been proven to lead to different forms of fraudulent behaviours amongst scholars, which can seriously effect the production of reliable and adequate new knowledge.[183]

In the case of studying the history of other cultures, Saliba explains that pressure from colleagues could also affect the quality of scholarly production:

[179] A.G. Wheeler, “The Pressure to Publish promotes disreputable science,” *The Scientist*, 3, 14, 11, Jul. 10, 1989. http://www.the-scientist.com/yr1989/jul/opin_890710.html
[180] *Ibid.*
[181] *Ibid.*
[182] *Ibid.*
[183] See, for example, W. William and W. Nicholas, *Betrayers of the Truth* (New York: Simon and Schuster, 1985).

> Those who work in Islamic studies within the Western cultural domain are under constant pressure from their colleagues who have no access to Islamic languages to translate, annotate, and pre-digest primary texts of Islamic civilization, in order to incorporate such texts into current critical discussions here in the West. [184]

These colleagues do not want "individually dissected texts," but "total pictures" that by their "very nature as historical texts tend to yield more than one reading and provide more interpretive choices."[185] In such an environment, adds Saliba, the "lessons learned from one text may very quickly be generalized and hasty conclusions drawn without justification."[186] This will occur at a time when the basic "stock-taking of Islamic culture (such as determining the existence of manuscripts, cataloguing collections, correcting outdated catalogues, reading existing and well-catalogued manuscripts, etc.) is hardly even begun."[187]

According to Saliba, this raises a number of important problems to do with the project of studying the production of another culture. More precisely, why do we study historical scientific texts and how should they be studied? Is such a study conducted in order to incorporate that production within the global picture of the researcher, and do all findings and results thus have to be couched in such a way that they make sense to the investigating culture? Or should the study be conducted with the view that members of the "native" culture could also

[184] George Saliba, "Writing the history of Arabic astronomy: problems and differing perspectives." *The Journal of the American Oriental Society,* 116, 4, Oct-Dec 1996, p.709 (10). Accessed online: http://web6.infotrac.galegroup.com/itw/infomark/796/299/33216084w6/purl=rc1_EAIM_0_A19404331&dyn=3!xrn_9_0_A19404331?sw_aep=griffith
[185] *Ibid.*
[186] *Ibid.*
[187] *Ibid.*

incorporate the results obtained from a specific historical text and thus the interpretation be addressed to them as well? The answers to such questions, explains Saliba, will determine the language of the text, the manner in which problems are posed, and will certainly determine the common ground from which one can address an audience.[188]

To summarise, the above constricting factors, working separately or in combination, can hinder the production of empirically supported knowledge. To give a practical illustration, an example from the writing of the history of Islamic astronomy will be considered.

7. Implications of Inadequate Scholarship: An Example From the Writing of the History of Islamic Astronomy.

The aim here is to highlight that the absence of some qualitative standards will lead to inadequate and, at times, incomplete scholarly work. The example used concerns the recent publication of two books dealing with one of the most important pre-modern Islamic astronomical texts, namely, the theoretical planetary work of al-Tusi. This section draws heavily on comments made by Saliba.[189]

Recently, F. J. Ragep and Dr. Abbas Sulaiman, published separate translations of al-Tusi's book called *Tadhkira* (Memoir on Astronomy.) F. J. Ragep called his translation *Nasir al-Din al-Tusi's Memoir on Astronomy*, and Dr. Abbas Sulaiman

[188] *Ibid.*
[189] Saliba, "Writing the history of Arabic astronomy: problems and differing perspectives," o*p.cit.*

called his *Nasir al-Din al-Tusi: al-Tadhkira fi ilm al-hay a ma a dirasat li-ishamat al-Tusi al-falakiya*.[190] Both books were published in the same year, but, according to Saliba, are worlds apart.[191]

Saliba explains that both books provide an edition of the Arabic text of Tusi's *Tadhkira*, but only Ragep's has an English translation and a commentary, addressed to the Western and international reader.[192] Indices and bibliographies are present in both books, but only "Ragep's has an extensive critical apparatus: maps, glossary of Arabic terms with their English translations and contextual references."[193] This is where the similarities end.[194] Saliba explains:

> A quick look at both books makes it obvious that Dr. Sulaiman's expertise in the field is vastly different from Ragep's, and illustrates very clearly the drawbacks of working (as Dr. Sulaiman did) without much in the way of institutional resources, libraries, collections of manuscripts, and the like.[195]

Saliba explains that Dr. Sulaiman's edition "ends up being an adequate attempt at informing the Arab reader of the contents of Tusi's work, while leaving that reader to his own interpretive devices regarding what Tusi was really trying to say."[196] Furthermore, Dr. Sulaiman's absence of a commentary and his "few

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191 *Ibid.*
192 *Ibid.*
193 *Ibid.*
194 *Ibid.*
195 *Ibid.*
196 *Ibid.*

introductory technical remarks in Chapter Three reveal very clearly that he himself does not have full mastery of the text."[197] Moreover, Saliba claims:

> Dr. Sulaiman is not even aware of the historical importance of the text. He is out of touch with the most recent literature on the subject, though he seems to have a vague impression that Tusi's text has something to do with the work of Copernicus (d. 1543) - hence its importance and, I presume, the reason for which he undertook his edition.[198]

On the other hand, Ragep's work is of greater value because:

> Not only is he "aware of the most recent analysis of Arabic astronomical theory and its relationship to Copernican astronomy, he is also engaged in it at the participant level and has spent more than twenty years in preparing, annotating, and reading almost every word that has been said about this text, whether useful or not. The result is clearly demonstrated by the level of mature analysis throughout the book.[199]

Thus, while both scholars speak Arabic and were able to edit al-Tusi's text, Ragep's expertise in the field plays a vital role in the production of a scholarly piece of work. Dr. Sulaiman approaches the text from a linguistic perspective, assuming that since the text is in Arabic, an Arab ought to be able to understand the text on his own, hence no need for further comments.[200] This attitude

[197] *Ibid.*
[198] *Ibid.*
[199] *Ibid.*
[200] *Ibid.*

"assumes that any native reader of a language can understand the contents of a text even if the text is highly technical in nature."[201]

Ragep, on the other hand, approaches the text with the assumption that a Western reader is ignorant of its contents, and hence it needs to be translated, annotated, and commented upon at almost every point.[202] Ragep does this "not only to convince himself that he has mastered the text, but also to make it accessible to any reader, who may or may not even be interested in the whole enterprise."[203]

Ragep and Sulaiman, therefore, produced two completely different treatments of the same text, both of which – Saliba explains - are almost completely unrecognisable to the readers of the other culture.[204] Furthermore, though there are very few variations in the textual readings between the two editions, the scholarly differences that "separates them has to do with the authors' understanding of the text and their varying use of its message."[205] Therefore, in the production of scholarly work, mastery of a language is necessary but not sufficient. A scholar needs to be well versed with the discipline he or she is researching.

This example illustrates a number of important points that relate to the scholarly community and the scholar. First, if communication is essential in a scholarly community (and it is), then clearly Ragep's work is better than Sulaiman's, in that Ragep spells out better exactly what the text means. Second, if a good grounding in the area matters for academics (and it does!) then again Ragep's work is better

[201] *Ibid.*
[202] *Ibid.*
[203] *Ibid.*
[204] *Ibid.*
[205] *Ibid.*

than Sulaiman's. Finally, if the quality of research is important for a scholar (and it is), then again Ragep's work is superior to Sulaiman's, in that Sulaiman's work has drawbacks in the way of institutional resources, libraries, collections of manuscripts, and the like. Clearly, Sulaiman's work is better than nothing, but from a scholarly perspective Ragep's work is far better.

SUMMARY AND CONCLUSION

The aim of this chapter has been to examine the nature of an ideal scholarly community, and the qualitative standards that it needs for, and the constricting problems that may hinder, the production of reliable knowledge. The chapter has highlighted a conceptual framework (a set of criteria) against which scholarly work may be measured. It is on the basis of this framework that an attempt will be made to examine the adequacy of the scholarly community in its endeavour to describe the fate of Islamic science. The chapter used a normative approach to examine what should be the case of an ideal scholarly community rather than what actually is. It has demonstrated that a scholarly community is a discourse community that is symbolically bonded by means of adequate communications, the absence of which renders scholarly production defective. It then categorised scholarship into six separate, but overlapping functions. It showed why these functions are vital to a scholarly community, and that it needs to be evaluated by a set of qualitative standards that capture and acknowledge what they share as scholarly acts. It also examined some problems that could hinder the production of adequate scholarly work.

It was also stated that works of scholarship involve a common set of qualitative standards: clear goals, adequate preparation, appropriate methods, significant results, effective presentation and reflective critique. These were articulated and it was explained that – collectively - these standards offer a powerful conceptual framework to guide evaluation of scholarship. The qualities of a scholar were then explained, including courage, persistence, consideration, humility and integrity. Integrity was a vital quality that also encompasses objectivity, honesty and fairness. Objectivity does not permit the scholar to hide some facts, nor to consider race, religion, or political party in a scholarly work. It was argued that these qualities are important because they shape the scholar's intellectual work and knowledge. The chapter then outlined some of the problems that may hinder the production of reliable knowledge. Amongst these were social psychological, intellectual, and procedural problems.

The chapter then illustrated, by way of example, from the writing of the history of Islamic astronomy, that inadequate scholarship produces inadequate results. Using this example it was deduced that the production of scholarly work does not only require mastery of a language but also proper expertise in a given discipline. Scholars should not also attempt to produce work due to pressure imposed by other colleagues. Saliba's work was used to raise some serious methodological problems associated with the project of studying the production of another culture. It was concluded that the 'why' and 'how' of such studies determine the language of scholarly work, the manner in which problems are posed, and will certainly determine the common ground from which one can address an audience.

Now that some idea of what should characterise a scholarly community exists, the next step is to examine the actual scholarship on the fate of Islamic science. Of course, one would not expect the ideal to be realised in full, but one might expect to see some approximation of it. The next chapter presents the first comprehensive review of scholarship on the fate of Islamic science from Ibn Khaldun to the present.

4

A COMPREHENSIVE REVIEW OF SCHOLARSHIP FROM IBN KHALDUN TO THE PRESENT

INTRODUCTION

Chapter Three examined the nature of an ideal scholarly community, and the qualitative standards that it needs for, and the constricting problems that may hinder, the production of reliable knowledge. The chapter highlighted a conceptual framework (a set of criteria) against which scholarly work may be measured. This chapter presents the first comprehensive review of scholarship on the fate of Islamic science between the eleventh and sixteenth centuries. For the period of Ibn Khaldun (1332-1406) to the present, this chapter presents an extensive critical review of both classical and contemporary scholarship, exclusively or partially, devoted to the question of the fate of Islamic science between the eleventh and sixteenth-centuries.[1] The aim will be to elucidate one key point: the adequacy (or inadequacy) of the scholarly community to explain what[2] happened to Islamic science between the eleventh and sixteenth-centuries.

The overall intent of this chapter is to show that scholars failed to build on the work of other scholars, ignored major pieces of evidence, and that in most cases

[1] Chapter One explained why this particular period is chosen.
[2] The aim is not to examine causal factors but what did scholars say about *what* happened to Islamic science. However, because theories and ideas of the fate of Islamic science are always associated with causal factors (why it happened), the chapter considers - in a preliminary way - the various problems that might be associated with these factors. Comments made about these are not aimed to be comprehensive. The aim is to range across various problems, drawing out elements useful for our purposes. These elements will be highlighted in the conclusion in a way that they can be used in subsequent chapters.

they were not trying to discern what happened to Islamic science but were referring to the subject as part of another project. The importance of this review lies in the fact that, for the first time, it exposes the inadequacy of the scholarly community in understanding one of the most challenging questions of the history of science.

Due to the absence of substantial theories[3] on the topic, it was necessary to review brief ideas[4] (opinions and views) pointing to the frequency of the latter and the virtual non-existence of the former. Thus, other than the usual reviews of books and articles, a range of methods was employed in this research. For instance, many journal databases were used to search for materials related to the topic.[5] In addition, personal communications with many prominent scholars were made.[6] These scholars were asked for specific information regarding the question of decline that they, or someone else, had written. Research was not restricted to the above methods only, but also more than one hundred and fifty *Arabic* classical texts on the history of Islamic civilization were also examined.[7] The present review is largely restricted to works published in English or Arabic and some

[3] Theory will mean here, "a logical group of statements used as principles to explain something." David Blair (ed), *The Pocket Macquarie Dictionary* (Milton: The Jacaranda Press, 1982), p.940.
[4] "Opinion, view or belief," *ibid.,* p.449.
[5] Including: Academic Press e-journals (multidisciplinary), Academic Research Library, Blackwell Science journals (multidisciplinary), Catchword e-journals (multidisciplinary), E*subscribe, Expanded Academic ASAP International, IngentaJournals (multidisciplinary), Kluwer e-journals (multidisciplinary), Wiley e-journals (multidisciplinary), and ScienceDirect, to name just a few.
[6] Amongst whom were: Seyyed Hossein Nasr, Ahmad Al-Hassan, Abdel-Hamid Sabra, George Saliba and even Alberto Elena (who was surprised to know that I have read a translated version of his Spanish paper).
[7] Including Ibn Khaldun's *Al-Muqaddimah,* At-Tabari's *Tarikh At-Tarbari*, and Al-Hanafi's *Kashf-al-Thunoon*, amongst many others. This research was possible using the 'Library of Islamic History and Civilisation' CD ROM (Turath: Amman, 1999).

French and Spanish material, but does not refer to work published in other languages.

IBN KHALDUN (1332-1406)

The first scholar (as far as this author knows) to give a comprehensive description of what happened to Islamic science is Ibn Khaldun. Considered the greatest Arab historian and the father of modern social science and cultural history,[8] Ibn Khaldun wrote a world history that aimed at an analysis of historical events. This work, commonly known as *Muqaddimah* (1377),[9] or 'Prolegomena,' was concerned with identifying psychological, economic, environmental and social factors that contribute to the advancement of human civilization and the currents of history.

Ibn Khaldun was not mentioned outside the Islamic world until the year 1636.[10] The first bibliography of Ibn Khaldun in Europe appeared in the year 1697 at the *Bibliothèque Orientale d'Herbelot*.[11] Copies of the *Muqaddimah* in Arabic existed in big libraries, such as the *Bibliothèque Nationale* in France, long before the work was translated.[12] W. M. de Slane first translated the *Muqaddimah* into French in 1862.[13] A new French translation by V. Monteil was done in 1967.[14] F.

[8] Mushin Mahdi, *Ibn Khaldun's Philosophy of History* (University of Chicago Press, 1971).
[9] Ibn Khaldun, 1332-1406. *The Muqaddimah: An Introduction to History*. Arabic. Trans. Franz Rosenthal. 3 vols. (New York: Pantheon Books, 1958). Though the translation by Franz Rosenthal is used for our purposes, however, it should be noted that this author reviewed Ibn Khaldun's original Arabic text: Ibn Khaldun, Abdul Rahman Muhammad. *Muqaddimat Ibn Khaldun*. [Arabic], 1 vols. (Beirut: Dar Al-Qalam, 1984).
[10] A. M. Al-Araki, *Ibn Khaldun: Discourse of the Method and Concepts of Economic Sociology* (University of Oslo, 1983). http://home.hio.no/~araki/arabase/ibn/khald201.html
[11] *Ibid.*
[12] *Ibid.*
[13] *Ibid.*
[14] *Ibid.*

Rosenthal first translated the *Muqaddimah* into English in 1958.[15] N. J. Dawood did an abridged edition of the *Muqaddimah* into English in 1967. A Portuguese translation by J. Khoury and A. Bierrenbach-Khoury was also done in 1958.[16] Though the translation by Franz Rosenthal is used for our purposes, it should be noted that this author reviewed Ibn Khaldun's original Arabic text. What follows then, is a review of Ibn Khaldun's explanations of the fate of Islamic science.

In a chapter titled "Scientific instruction is a craft,"[17] Ibn Khaldun explains that scientific instruction in the lands of the Maghrib has "practically ceased to be cultivated"[18] amongst the inhabitants. This is because the civilization of the Maghrib has:

> Disintegrated and its dynasties have lost their importance, and this has resulted in the deterioration [*naqs*] and disappearance [*fuqdān*] of the crafts.[19]

Ibn Khaldun explains that when the civilization of Spain was highly developed, and sedentary culture was well established, the "sciences and crafts were greatly cultivated and very much in demand."[20] But when the Maghrib and Spain "fell in ruin, scientific instructions ceased (to be cultivated) [*qad kāda an yanqati'*] in the West [of the Islamic Empire]."[21] The emphasis here is on 'scientific instruction,' which means the education of science and not necessarily its activity.

[15] *Ibid.*
[16] *Ibid.*
[17] Ibn Khaldun, Trans. Franz Rosenthal, vol. 2, 426.
[18] *Ibid.,* 427.
[19] *Ibid.*
[20] *Ibid.*
[21] *Ibid.*

Nevertheless, similar observations are noted in another chapter titled "The various kinds of intellectual sciences,"[22] but the emphasis this time is on 'scientific activity.' Here, Ibn Khaldun explains that science in the Maghrib and Spain "decreased [*tanāqasat*] with the decrease of civilization."[23] Consequently:

> Scientific activity disappeared [*'Id}mah}alat*] there, save for a few remnants that may be found among scattered individuals and that are controlled by the orthodox religious scholars.[24]

Ibn Khaldun suggests that something else happened in other parts of the Islamic Empire. With the exception of Baghdad, al-Basra and al-Kufa, which fell in ruin,[25] the tradition of scientific instruction *did not* decrease nor cease to be cultivated in the Eastern part of the Empire. Prior to their ruin, however, Ibn Khaldun explains that Baghdad, al-Basra and al-Kufa were the "(original) mines of scholarship."[26] After they were ruined:

> Science was transplanted [*'intaqala*] from the (early centres) to the non-Arab 'Iraq of Khurasan, to Transoxania in the East, and to Cairo and adjacent regions in the West.[27]

[22] *Ibid.,* vol.3, 117.
[23] *Ibid.*
[24] *Ibid.*
[25] *Ibid.,,* vol.2, 431.
[26] *Ibid.*
[27] *Ibid.*

In another chapter titled "The sciences are numerous only where civilization is large and sedentary culture highly developed,"[28] Ibn Khaldun elaborates on the above observation, saying:

> This may be exemplified by our previous statements concerning Baghdad, Córdoba [Spain], al-Qayrawān [the Maghrib], al-Basra and al-Kufa. At the beginning of Islam, the civilizations (population) were large, and sedentary culture existed in them. The sciences were then greatly cultivated there, and the people were widely versed in the various technical terminologies of scientific instruction, in the different kinds of sciences, and in posing problems and (inventing new) disciplines. They exceeded (all) who had come before them and surpassed (all) who came after. But when the civilization of those cities decreased and their inhabitants were dispersed, the picture was completely reversed. Science and scientific instruction no longer existed[29] in those cities, but were transplanted to other Muslim cities" [30]

Ibn Khaldun is emphasising that the sciences were cultivated in Baghdad, Córdoba, al-Qayrawān, al-Basra and al-Kufa when civilisational factors were favourable. But when these decreased, science and scientific instruction no longer existed in those cities and were transplanted to other Muslim cities. According to Ibn Khaldun, the regions in which science prospered were those cities whose prosperity and civilization did not decrease. To elucidate his point further, Ibn Khaldun explains:

[28] *Ibid.,,* vol.2, 434.
[29] An alternative, and perhaps more accurate, translation would be 'lost in them.'
[30] *Ibid.,*

> We, at this time, notice that science and scientific instructions exists in Cairo in Egypt, because the civilization of (Egypt) is greatly developed and its sedentary culture has been well established for thousands of years. Therefore, the crafts are firmly established there and exist in many varieties. One of them is scientific instruction.[31]

Ibn Khaldun is clearly saying that science and scientific instructions *existed* in Cairo and other cities, when in other regions of the Eastern Islamic Empire they did not. This observation shows that Ibn Khaldun has a highly sophisticated grasp of what can happen to an endeavour like science, and he clearly shows that different areas can suffer differing fates. Overall, Ibn Khaldun suggests three distinct observations:

1. Science and scientific instruction *decreased* and eventually *disappeared or ceased* to be cultivated in the Maghrib and Spain simply because these countries were ruined;
2. Science and scientific instruction in Baghdad, al-Basra and al-Kufa *no longer existed*, and were *transplanted* to other regions of Islam;
3. Science and scientific instruction *existed* in other Muslim lands like Egypt at a time when they ceased in certain places and were transplanted in others.

It is important to note that ibn Khaldun's observations are multi-faceted, and they

[31] *Ibid*., vol. 2, 343.

show that different things happened to science in different parts of the Islamic world. However, we now know that they are not entirely comprehensive. He could, for example, have spelled out a good deal more about what happened to science in other places of the Islamic Empire such as Persia, in which astronomy flourished up to the sixteenth century.[32] Ibn Khaldun's work is very important, and one would expect that any scholarly discourse on what happened would show awareness of it, and build upon it to provide a more comprehensive alternative.

ERNEST RENAN (1823-1892)

In 1883, twenty-one years after the French translation of the *Muqaddimah*, the French pioneer of philology Joseph Ernest Renan published an influential essay entitled *L'Islamisme et la science*. In it Renan states that Islamic science declined after its golden age because of racial factors, but he placed greater emphasis on the intolerance Islam had for reason.[33]

Renan, borrowing the idea from the French philosopher Voltaire, declared, "the Oriental mind is incapable of rational thought and philosophy and was responsible for blocking the development of science and learning in the Muslims world."[34] More bizarre was Renan's claim that the 'little science and philosophy that Muslims had produced was the result of a rebellion against Islam,'[35] and that

[32] See Ahmad Y. Al-Hassan, "Factors behind the decline of Islamic science after the sixteenth century," in Sharifah Shifa Al-Attas (ed), *Islam and the challenge of Modernity: Historical and contemporary contexts* (Kuala Lumpur: International Institute of Islamic Thought and Civilisation, 1996).
[33] Cited in T.H. Huff, *The rise of early modern science* (Cambridge: Cambridge University Press, 1993), p.53.
[34] Renan quoted in Sardar, *op.cit.*, p.50.
[35] *Ibid.*

science could only flourish in Islam in association with heresy.[36] Renan further states that "the Mussulman [Muslim] has the most profound disdain for instruction, for science, for every thing that constitutes the European spirit."[37]

MAX WEBER (1864-1920)

The great German sociologist Max Weber shared similar views to Renan. Weber has become one of the monumental figures of social science. His sociological and political concepts are part of the working vocabulary of social scientists. His work has illumined several fields of sociology and political science and is of special importance in the study of economic history and in the investigation of the links between religion and society.[38] Weber suggests that Islamic science declined because the Arabs were less intelligent than the Europeans, who had a superior collective mind.[39] He states:

> Europeans are genetically endowed with comparatively greater amounts of rationality, thereby allowing for the speedier development of a rational capitalist ethic. [40]

The absurdities of these racial "explanations" are obvious, and are fortunately no longer repeated. If the Muslims contributed some of the best science in history, it is absurd to claim that Islamic science declined due to racial factors. Furthermore,

[36]Bryan S. Turner, *Orientalism, Postmodernism & Globalism* (New York: Routledge, 1994), pp. 30-31.
[37] Ernest Renan in *Ibid.*
[38] Max Miller, S. M. Miller and Walter Garrison Runciman, *Max Weber* (Thomas Y. Crowell Company, 1963), p.1.
[39] In P. Hoodbhoy, *Islam and Science: Religious Orthodoxy and the battle for Rationality* (Pakistan: Zed Books, 1992), p.2.
[40] *Ibid.*

the fact that Islamic science was a product of people of many ethnic backgrounds (not only Arabs), and that there is today a rapid growth of science and technology in many non-European countries provides a clear-cut refutation of such reasoning.

Compared to Ibn Khaldun's observations, Renan and Weber's decline notion can be criticised as factually mistaken, or at least grossly over-simplified. While these racial factors are outdated, the decline thesis persisted in the course of nineteenth and twentieth century Orientalist's literature, where polemical denigration informed Western scholarly pronouncement. It can be assumed that this perspective is the product of the prevalent notion that Islam was simply a vehicle transmitting Greek science to the Renaissance in Europe. More so, it is a result of belief that Islam is "deficient in vitality," and "carrying in its bosom the seeds of decay,"[41] and that decline was "the inherent characteristic of Islamism."[42]

Renan and Weber can be excused on the grounds that the findings of modern scholarship were not available at their time. But in the light of the fact that the *Muqaddimah* was translated into French as early as 1636 - it is reasonable to expect that they show awareness of Ibn Khaldun's observations, which in any case dispels the notion of a uniform decline.

GEORGE SARTON (1884-1956)

George Sarton is one of the most important figures in the history of the History of Science. He defined much of its content, suggested the basic questions and

[41] Quoted by Martin Kramer, "Coming to terms: Fundamentalists or Islamist?" *Middle East Quarterly*, Spring 2003, pp.65-77.
[42] *Ibid.*

methods, and produced several important books. In his monumental *Introduction to the History of Science*,[43] Sarton marks the time from the second half of eighth century to the second half of the eleventh century as the period where Islamic science flourished.[44]

While recognizing that the golden age continued into the second half of the eleventh century, Sarton believes that it had "culminated in the first half of the eleventh century."[45] And "though intellectual activity was still very intense and of very high order during the second half,"[46] Sarton claims:

> There was already a perceptible *decline* [my italics] both in the quality and the quantity of the effort. This is not recognized at once, because the decline is very small and is hidden by the activity of some very great personalities.[47]

Sarton suggests that Islamic science declined because of the Eastern people's inability to find, understand, or apply the experimental method. Thus, while "the Western people found the cure, the only cure, the experimental method; the Eastern people did not find it, or did not fully understand it, or neglected to apply it."[48] Sarton offers no suggestions that may explain this inability, and simply

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[43] George Sarton, *History of Science* (New York: Krieger, 1927).
[44] Sarton divides this period into: The time of Jabir Ibn Hayyan which covers the 2nd half of eighth century; The time of Al-Khawarizmi which covers the 1st half of ninth century; The time of Al-Razi which covers the 2nd half of ninth century; The time of Al-Mas'udi which covers the 1st half of tenth century; The time of Abu-l-Wafa which covers the 2nd half of tenth century; The time of Al-Biruni which covers the 1st half eleventh century; and the time of Omar Khayyam which covers the 2nd half of the eleventh century.
[45] *Ibid.,* vol.1, p.738.
[46] *Ibid.*
[47] *Ibid.*
[48] *Ibid*., p.29.

brushes aside this intriguing question by stating, “it is impossible to answer.”[49] Sarton repeats the decline theme presented by Renan and Weber, but differs on causes. Sarton also gives a ‘precocious child’ explanation for the decline:

> Perhaps, that the Eastern people, say the Muslims, had reached the limit of their development, that they were like those gifted children who startle the world by their precocious achievements and then suddenly stop and become less interesting, while others, at first less brilliant, pass far ahead of them.[50]

This precocious child explanation is absurd, for there is little meaning in saying that the leading civilisation on the planet – most advanced in science and scholarship in general – was like a precocious child. This explanation says nothing more than that science declined; thus it can be dismissed entirely. Overall, Sarton’s observations are a brief and superficial treatment of what happened. However, it is worth noting that Sarton stresses intellectual activity, and that ‘decline’ must be looked at both in *quality* and *quantity*. This gives us a clue as to how to apply a more sophisticated view: look at both quality and quantity of scientific work in different areas at different times. Of course, this is not fully satisfactory, but it is more than nothing.

WILLIAM CECIL DAMPIER (1867 - 1952)

In 1929, two years after Sarton’s publication, the British scientific writer Sir

[49] *Ibid.,* p.29.
[50] *Ibid*., p.29.

William Cecil Dampier published his book *History of Science and its Relation with Philosophy and Religion*, in which he also assumed that by the close of the eleventh century:

> The decline of Arabic and Muslim learning had set in, and henceforth science was chiefly a European activity."[51]

We shall not elaborate further on Dampier's decline idea, simply because he himself does not add any more to what was already said. Nevertheless, it was important to highlight the brief views of Dampier in order to show that the theme of decline is repeated again in literature that belonged to the same period of Sarton. A similar theme is reproduced in the work of other distinguished scholars of the same period, including Carra de Vaux.

CARRA BERNARD DE VAUX (1867-1950)

The French Orientalist Baron Carra is not as well known as some of the above scholars. Nevertheless, he spent a lifetime studying medieval Islamic science. In 1932 he published a chapter on "Astronomy and Mathematics" in *The Legacy of Islam*.[52] Carra de Vaux does not specifically tackle the thorny question of what happened, but he offers a scanty suggestion. Carra de Vaux explains that:

[51] Sir William Cecil Dampier, *History of Science and its Relation with Philosophy and Religion* (Cambridge: Cambridge University Press, 1929), p.76.
[52] Baron Carra de Vaux, "Astronomy and Mathematics," in Sir Thomas Arnold and Alfred Guillaume (eds), *The Legacy of Islam* (Oxford: Clarendon Press, 1931), pp.376-97.

> Such then in its broad outlines was the scientific work of the Arabs. It came to an end when that of the Western genius began, that is to say in the fifteenth century. It is sometimes asked what were the causes of this cessation of intellectual activity in the Muslim world. Whence came this torpor after a period of such prolific activity? This, however, is a question, which raises very obscure problems of general psychology about which no one has yet put forward any very definite theory and, as I have none to propound myself, I do not think I ought to attempt to discuss it.[53]

Carra De Vaux's conclusion is interesting because he is not talking at all about decline. In fact, he is suggesting that Islamic science continued for a while after the eleventh century and only "came to an end…in the fifteenth century."[54] Nothing is mentioned regarding what happened in between the eleventh and fifteenth century. In view of the evidence available this is a correct observation. Certainly it fits well with Ibn Khaldun's observations, although de Vaux does not refer to them.

MAX MEYERHOF (1874-1945)

Max Meyerhof is the great historian of Jewish and Islamic medicine and eminent ophthalmologist and translator. He also published a chapter on "Science and Medicine"[55] in 1932 in the same book *The Legacy of Islam*. But Meyerhof offers an entirely different explanation to that of de Vaux. He suggests that Islamic

[53] *Ibid.,* p.397.
[54] *Ibid.*
[55] Baron Carra de Vaux, "Astronomy and Mathematics," in Sir Thomas Arnold and Alfred Guillaume (eds), *The Legacy of Islam* (Oxford: Clarendon Press, 1931), pp. 376-97.

science declined beginning from about 1100 because of the work of al-Ghazali (d.1111).[56] Later in the same chapter, Meyerhof contradicts this by stating; "the twelfth century marks a standstill"[57] for science. Regarding Islamic medicine, Meyerhof explains that:

> With the beginning of the fourteenth century magic and superstitious practices began to creep into medical works of the Muslim writers, whose medical knowledge was often derived from religious writings. There is thus a further deterioration of the general standard of the material.[58]

Later on Meyerhof explains: "In the sciences other than medicine the output of books during the period of decline was very great, but the deterioration no less marked."[59] In summation Meyerhof is saying:

1. Islamic science declined beginning from about 1100
2. The twelfth century marks a standstill
3. With the beginning of the fourteenth century further deterioration of the general standard of the material occurred

Meyerhof's proposition has contradictions. Certainly, Islamic science cannot both decline and come to a standstill at the same time. Deteriorate could mean decline but cannot imply standstill either. Decline can mean a "gradual decrease or

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[56] Max Meyerhof, "Science and Medicine," in Sir Thomas Arnold and Alfred Guillaume (eds), *The Legacy of Islam* (Oxford: The Clarenda Press, 1931): p.337.
[57] *Ibid*
[58] *Ibid.,* p.339.
[59] *Ibid.,* p.341.

deterioration or decay or loss of vigour."[60] It can also mean, "to decrease in strength, character, value, etc."[61] On other hand, standstill means, "a state characterised by absence of motion or of progress."[62] Synonyms are: stay, still stand, and stop. Other related words are: arrest, check; pause; cessation, and halt.[63] In view of the fact that Ibn Khaldun showed that science existed beyond the dates suggested by Meyerhof, his conclusion is erroneous. Interestingly, not only is Meyerhof's explanation different from de Vaux's, but also neither of the two scholars draws on the work of the other. This is a serious problem in scholarship.

GUSTAVE VON GRUNEBAUM (1909-1972)

Von Grunebaum wrote a number of influential studies of macro-cultural problems relating to the unity of Islamic history and society. According to Turner, Von Grunebaum is characterised as the "historian of Islamic decadence and retreat."[64] According to von Grunebaum, the decline of Islam was "crucially bound with the problem of its sacred law tradition which could not be rapidly developed to meet entirely new circumstances and exigencies of social development."[65] He believed that the "steady decay"[66] of Islam began " early as the ninth century,"[67] and by "the middle of the tenth century ruined the central authority of Baghdad beyond repair."[68]

[60] B. Moore, *The Australian Oxford Dictionary (*Oxford*:* Oxford University Press, 1999).
[61] D. Blair, *The Pocket Macquarie Dictionary* (QLD: The Jacaranda Press, 1982).
[62]*Merriam-Webster On-Line Dictionary.* http://www.m-w.com/cgi-bin/dictionary
[63] D. Blair, D., *The Pocket Macquarie Dictionary*, *op.cit*., p. 883.
[64] Bryan S. Turner, *Orientalism, Postmodernism & Globalism*, *op.cit*., p.69.
[65] *Ibid.*
[66] Quoted in *Ibid.*
[67] *Ibid.*
[68] *Ibid.*

In terms of science, von Grunebaum "decides to ignore those developments in experimental science and technology which are apparently characteristics of Islam."[69] He suggests "that the need to maintain the authority of revelation over reason put definite limits on the impact of Greek science and philosophy on Islamic thought."[70] Writing in 1946, von Grunebaum believes that Islam suffered from conservatism and lack of cultural integration, thus:

> Conservatism…and the tendency natural to despotism and orthodoxy to discharge revision and reform, combined with Islam's catholic curiosity and receptiveness, are responsible for that lack of integration of the component elements which makes Islamic civilisation look like a torso…Arrested in its growth during the eleventh century… It stagnated in self-inflicted sterility.[71]

Von Grunebaum believes that Islamic scientists did "inventions, discoveries and improvements," but these "were hardly ever searched for."[72] This is because "the relative backwardness of Islam was never quite to be eliminated, owing to the understandable reluctance of the later generations to part with the association of the hallowed origins."[73] Von Grunebaum also asserts, "when Ibn Tumlus [d.1223] wrote, the productive age of Muslim research had come to a close."[74]

[69] Turner, *Ibid.,* p.71
[70] *Ibid.,* pp. 70-71.
[71] G. E. von Grunebaum, *Medieval Islam: A Study in Cultural Orientation* (Chicago: University of Chicago press, 1946), p.322.
[72] *Ibid.,* p.343.
[73] *Ibid.,* p.323.
[74] *Ibid.*

While von Grunebaum's suggestions echo earlier Orientalists' suggestions, he shows awareness of Ibn Khaldun's observations regarding what happened, but inadequately represents it. Explaining Ibn Khaldun's observations, Von Grunebaum begins by telling us that Ibn Khaldun "was keenly conscious of the cultural *decline* [emphasis added] of the period."[75] Von Grunebaum then sums up Ibn Khaldun's observations saying:

> …with the extinction of scientific knowledge, civilisation had perished throughout the Muslim West. Only faint traces of scientific erudition remain, and its representatives are forced to evade the surveillance of the orthodox doctors. In southern Persia and Transoxania, also in Egypt, the situation is slightly more encouraging. "[76]

Von Grunebaum's treatment of Ibn Khaldun is problematic for a number of reasons. First, he tells us that according to Ibn Khaldun "civilisation had perished throughout the Muslim West" because of "the extinction of scientific knowledge."[77] He implies that the civilisation of the Muslim West perished because scientific knowledge became extinct. That is, he implies that civilisation is dependent on science. Ibn Khaldun's statement is saying exactly the opposite - scientific instruction and activity ceased because the Muslim West fell in ruin. Ibn Khaldun does not attribute the ruin of civilisation to the extinction of scientific knowledge. There is a huge difference in both understandings.

Von Grunebaum's inadequate representation is also visible in his assertion that

[75] *Ibid.,* p.339.
[76] *Ibid.*
[77] *Ibid.*

Ibn Khaldun claimed, "only faint traces of scientific erudition remain, and its representatives are forced to evade the surveillance of the orthodox doctors."[78] Von Grunebaum's statement implies that orthodox scholars showed resentment towards the representatives of scientific erudition, and thus were a cause of the decline of science. Ibn Khaldun *did* say that scientific activity disappeared in the Muslim West "save for a few remnants," but he *did not* claim its representatives were "forced to evade the surveillance of the orthodox doctors," as von Grunebaum would suggest. Ibn Khaldun said that these few remaining remnants "may be found among scattered individuals and that are controlled by the orthodox religious scholars."[79] This could mean that the orthodox religious scholars actually helped in protecting proper science from the occult sciences.[80]

Finally, von Grunebaum states that according to Ibn Khaldun that: "in southern Persia and Transoxania, also in Egypt, the situation is slightly more encouraging." Not only does this statement depicts a misleading picture of the scientific activity in these areas, but also is contradicted by Ibn Khaldun's observations that "science and scientific instruction exists in Cairo in Egypt, because the civilisation

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[78] *Ibid.*

[79] Ibn Khaldun, *The Muqaddimah, op. cit.,* vol.3, 117.

[80] This view has its historical backup as in the case of the orthodox scholar Ibn Qayyim al-Jawziyya (1292-1349). His attack on what he saw as the "threat to religion and civilisation" is found in his book *Miftah dar al-Sa'ada*, "a major section of which is devoted to disproving the occult sciences," especially alchemy, astrology and augury. Ibn al-Qayyim "employed science to defend a purified rational science and logic free of transmutational alchemy, astrology and augury that he saw as having displaced true science." Based on principles of Islamic law and pure science, Ibn Qayyim al-Jawziyya attacked the occult, especially astrology, on three levels:
(1) On the historical, by examples of important dynasties whose court astrologers advised them to act in accordance with a horoscope that in the event turned out to be wrong;
(2) On the technological, by arguments of earlier authoritative scientists that the tools of observation and tables of planetary positions failed to meet the exactitude required by a possible science of astrology;
(3) And on the scientific, revealing the arbitrary conventions and contradictions of the principles underlying astrology.
See J. W., Livingstone, "Science and the Occult in the thinking of Ibn Qayyim Al-Jawziyya," *The Journal of the American Oriental Society*, 112, 4, Oct-Dec 1992, p.1-2.

is greatly developed." Additionally, von Grunebaum completely missed Ibn Khaldun's observations that science and scientific instruction no longer existed in Baghdad, al-Qayrawān, al-Basra and al-Kufa, and that they were transplanted to other regions of Islam.

Von Grunebaum leaves us with a thesis that suggests that there was little science done in Islam, and that it eventually "stagnated in self-inflicted sterility."[81] Despite von Grunebaum's awareness of Ibn Khaldun's multi-faceted observations, he misrepresents them. Overall, there is curiously little significant intellectual development in von Grunebaum's view; little development in the gap of scholarship; and no change in the common Orientalist's account of the failure-centeredness of science in classical Islam. In the light of the work of Ibn Khaldun and the evidence available at the time, Grunebaum's observations about what happened are clearly mistaken.

J. D. BERNAL (1901-1971)

In science, Bernal was a pioneer in understanding the interrelation between structures and functions in physical, chemical and biological systems. On social questions he was a path breaker who tried to explore the relationship between the functions of science and the structure of the society in which it operates. In 1954 Bernal published his monumental *Science in History*.[82]

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[81] Grunebaum 1946 *op.cit.*, p.322.
[82] J. D. Bernal, *Science in History*, (Harmondsworth: Penguin Books, 1954).

Regarding the fate of Islamic science, Bernal explain, "Although there was no spectacular collapse," after the eleventh century, "it is evident that the best days of Islamic science were over."[83] Bernal acknowledges that Islam, as a religion and a civilization, still survives, but "it was not to regain the same scientific impetus that marked its first flowering."[84] So what happened to this scientific impetus? Bernal believes that it "stayed substantially frozen at the stage it had reached in the eleventh century."[85] The reason for this is "the rise of the clerical faction which actively discouraged philosophy and science."[86] Bernal says nothing else on this topic.

In common with previous scholars, Bernal repeats an idea that is devoid of historical accuracy and objectivity. He does not define the meaning of 'frozen,' which could mean a number of things: to become fixed or motionless, standstill, incapable of being changed, stopped, fixed or unmoving.[87] If these meanings are implied (and it seems they are), then Bernal is implying that Islamic science became fixed, stopped and became incapable of change after the eleventh century. This is equivalent to Meyerhof's view that Islamic science came to a standstill. Bernal's view is problematic for a number of reasons.

It was already said that from the 1950s onwards, an unprecedented acceleration of research on Islamic science began to change conventional understanding of the history of Islamic science. Thus, had Bernal built on this scholarship he would

[83] *Ibid.,* p.281.
[84] *Ibid.,* p.283.
[85] *Ibid.,* vol.1, p.283.
[86] *Ibid.*
[87] Blair, *The Pocket Macquarie Dictionary*, *op.cit.,* p.364 and *Merriam-Webster On-Line Dictionary.* http://www.m-w.com/cgi-bin/dictionary

have realised that Islamic science did not freeze after the eleventh century. Second, Bernal shows no awareness of Ibn Khaldun's work, although it had already been translated and was available in the West. Nor does he show awareness of von Grunebaum's work, which itself refers to Ibn Khaldun's theory.

In short, despite the fact that by his time some research was available to dispel the notion that Islamic science froze in the eleventh century, there is a striking relationship between Bernal's view and the repetitious, mimetic character of previous scholars like Meyerhof. Bernal's scholarship shows no intellectual development in explaining what happened; it marks a return to poor scholarship, and further highlights the gap in scholarship.

AYDIN SAYILI (1913-1993)

In 1960 Sayili wrote the classic work *The Observatory in Islam and its place in the general history of the observatory*.[88] In this work, Sayili devotes an appendix on: "The causes of the decline of scientific work in Islam."[89] Clearly, the idea of decline has not disappeared in Sayili's work. But this is the first serious work to discuss the causes of decline; define its meaning, and devises useful concepts to understand the meaning of decline.

Sayili defines the "decline" of science in Islam as being "the decrease of the energy and vitality of and the genuine interest in scientific work found in the ninth

[88] Aydin Sayili, *The Observatory in Islam and its place in the general history of the observatory* (Ankara: Türk Tarih Kurumu Basimevi, 1960).
[89] Aydin Sayili, "The causes of the decline of scientific work in Islam," in *Ibid.,* Appendix II, 407-429.

and tenth centuries especially".[90] Furthermore, Sayili emphasises that:

> Scientific work was of course far from coming to a standstill during the later centuries, but the pace diminished and slowed down. It is reasonable to think that had the momentum and intensity of the scientific activity of the earlier centuries continued unabated, Islam's scientific contribution to the world would very likely have been of considerable increased magnitude. The causes of decline of scientific work in Islam constitute therefore a very interesting subject of inquiry. [91]

Later in his paper, Sayili uses the term 'stagnation' as synonymous with 'decline' to describe what happened to Islamic science after its golden age, as is clear from his statement "…another assumption generally implied by the study of the causes of the stagnation or decline of science in Islam…"[92] Sayili uses the term stagnation again when he states that "the stagnation of science should perhaps be considered at least as natural as its progress."[93] But decline and stagnation are not synonymous.

Sayili then echoes the 'torch' theory of progress to explain what happened to Islamic science. Thus, he explains that although "Islam did not produce Galileos, Keplers, and Newtons, she prepared the groundwork for the ultimate emergence of the new scientific era in Europe."[94] Furthermore:

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[90] *Ibid.,* p.408.
[91] *Ibid.,* p., 412
[92] *Ibid.,* p.408.
[93] *Ibid.,* p.409.
[94] *Ibid*., p.410.

> Islam played its part by enhancing the dignity of Greek science and also by enriching it materially; but perhaps she thereby used much of her force, and when the torch of science went to another society which was eager to cultivate it, its very passage to a new environment with fresh possibilities of development for science constituted a change favourable to its progress."[95]

Sayili then proceeds to explain that the words "decline," or "stagnation" as applied to the course of science in Islam need clarification:[96]

> …the decline in science may thus be defined in a simple manner as decrease of dynamism in science… it does not mean a decrease in the amount of knowledge in circulation or available for circulation… It is a decline in the magnitude of scientific work and achievement, in scientific productivity, in the frequency of occurrences of original contributions to scientific knowledge.[97]

Sayili also explains that Islamic science declined because there was:

> …a gradual, if not uniform, decrease both in the intensity of production of first-rate work, and in the frequency of appearance of first-class scientists...who did not disappear during the later centuries, but they became increasingly rare.[98]

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[95] *Ibid.,* p.410-11.
[96] *Ibid.,* p.412.
[97] *Ibid.*
[98] *Ibid*., pp. 412-13.

In addition, and of equal importance, is the fact that Sayili recognises that the decline in science:

> …was not always conspicuous; at times it was not uniform and continuous, and it was not simultaneous or of equal magnitude in all scientific fields and geographical regions."[99]

Sayili's definition of decline, and the concepts he applies, are significant because they mark a departure from previous scholarship. So far, Sayili is the only scholar who is saying that Islamic science declined because there was a decrease in the magnitude of scientific work and achievement, scientific productivity, and frequency of occurrences of original contributions to scientific knowledge. In addition, his recognition that Islamic science could have suffered different fates in different regions is of equal significance, because it is the first scholarship that is beginning to highlight something that Ibn Khaldun observed six centuries earlier.

However, Sayili's treatment of the fate of Islamic science is problematic for a number of reasons. First, he suggests that the terms decline and stagnation are synonymous, which is clearly incorrect. Second, while he recognises that decline did not happen uniformly and continuously in all scientific fields and geographical regions, he offers a one-dimensional, single faceted solution – that of decline. Could not different things have happened to different fields of Islamic science in different regions? Ibn Khaldun certainly showed that. Sayili failed to do so! Nonetheless, certain important definitions and parameters pertaining to the

[99] *Ibid*, p.412.

concept of decline can be derived from Sayili's work. These parameters state that decline in Islamic science:

(1) Does not mean a decrease in the amount of knowledge in circulation or available for circulation

(2) Is a decline in the magnitude of scientific work and achievement, in scientific productivity, in the frequency of occurrences of original contributions to scientific knowledge

(3) Is a gradual, if not uniform, decrease both in the intensity of production of first-rate work, and in the frequency of appearance of first-class scientists...who did not disappear during the later centuries, but they became increasingly rare.

(4) Was not always conspicuous; at times it was not uniform and continuous, and it was not simultaneous or of equal magnitude in all scientific fields and geographical regions.

PHILIP KHURI HITTI (1886-1978)

The late Phillip Hitti, the Lebanese-born Professor Emeritus of Semitic Literature at Princeton, was one of the world's leading Arabic scholars and authorities on the Near East. He has written many books, including *History of the Arabs* (1937, 8^{th} edition 1964), and *The Arabs: A short History* (1968). In his book *The Arabs: A Short History*, Hitti claims:

> When the *Arabian Nights* had been put into final form in Arabic the golden age of Moslem scientific and literary progress had of course ended. In no branch of pure or physical science was any appreciable advance made after Abbasid days…In medicine, philosophy, mathematics, botany and other disciplines a certain point was reached – and the mind of Islam seemed to standstill.[100]

Two years after the publication of this book, Hitti published his *Islam: A Way of Life* (1970)[101] in which he devotes a chapter on "Arab science," wherein he says nothing about the fate of Islamic science. The *Arabian Nights* was drafted in the tenth century by al-Jahshiyari (died in 942),[102] accordingly Hitti suggest that the tenth century marked the end of the "golden age of Moslem scientific and literary progress." Clearly, this conclusion is wrong. It shows Hitti's neglect of the works of previous scholars such as Sarton and Sayili, which shows that the tenth century did not mark the end of Islamic science.

In addition, Hitti was aware of the *Muqaddimah* (because he refers to it in his book), but fails to show any awareness of Ibn Khaldun's multi-faceted observations. Hitti's conclusion shows lack of knowledge of the work of scholars like Sarton, who wrote *Introduction to the History of Science* (1927) forty-one years earlier. Sarton stated that Islamic science began to decline after the second half of the eleventh century, and not the tenth century, as Hitti suggests. More important, Hitti shows no awareness of Sayili's work, which demonstrates with clear evidence that the pace of scientific work in Islam did not come to a standstill

[100] Phillip Hitti, *The Arabs: A Short History* (London: Macmillan, 1968), fifth edition, p. 117.
[101] Phillip Hitti, *Islam: A Way of Life* (London: Oxford University Press, 1970).
[102] *Ibid.*

in the tenth century. By Hitti's time sufficient information was available to dispel his 'standstill' idea. Hitti's conclusion provide nothing useful to help understand the fate of Islamic science, and demonstrates an enormous gap in, and return to, poor scholarship.

JOHN JOSEPH SAUNDERS (1910-1972)

Saunders was an historian who also wrote on Medieval Islam. Amongst his books is, *History of Medieval Islam* and *Muslims and Mongols: Essays on Medieval Asia* (1977).[103] This book is an introduction to the history of the Muslim East from the rise of Islam to the Mongol conquests. It explains and indicates the main trends of Islamic historical evolution during the middle Ages. In a chapter titled "The problem of Islamic decadence" Saunders starts by reviewing some Western historians' explanations of the causes of the decline of the Islamic empire. Saunders states that not until "the Age of Enlightenment did the West awake to the fact that its enemy and former mentor [Islam] had slipped so far behind: only then were attempts made to account for this decline."[104] Here, Saunders is talking of decline, but he does not use this term again, instead he claims that Islamic science decayed. Saunders explains that decadence is " more easily employed than defined."[105] Saunders then explains that to apply the concept of decadence to "art or literature is risky: who is to decide whether Gothic architecture is inferior to Baroque or Byzantine?" Consequently, he offers what he calls "a more satisfactory test," which is:

[103] J. J. Saunders, *Muslims and Mongols: Essays Medieval Asia* (University of Canterbury: Whitcoulls Ltd., 1977).
[104] *Ibid.*, p.101.
[105] *Ibid.*, p.104.

> …to measure the accumulation of positive knowledge in a given society: if that society at a particular stage in its history fails to add to the knowledge previously acquired but actually loses a portion of it, then it may be properly labelled decadent.[106]

Accordingly, Saunders continues, "we may speak of a decline of classical civilization from the second century onwards,"[107] because "Hellenic science made no real advance after Ptolemy."[108] On the other hand, "the educated subjects of the last Constantine probably knew no more than those of Justinian: they read Homer and Plato, and preserved the priceless heritage of classical Greek culture, but they added nothing to the stock of human knowledge."[109] As a consequence, "Byzantium was static rather than decadent," because "during the millennium of her existence if nothing was lost, little was gained."[110] Hence, explains Saunders, "it is in this sense of intellectual (not literary or artistic) backwardness that Islam may be fairly charged with decadence,"[111] because:

> It created or presided over the creation of a rich and widely diffused culture, which despite heavy borrowing from Greek and other sources was yet truly original. But after a few centuries, the stream of creative thinking evaporated, the pursuit of knowledge for its own sake was severely discouraged, and the most promising lines of inquiry were never followed

[106] *Ibid.*
[107] *Ibid.*
[108] *Ibid.*
[109] *Ibid.*
[110] *Ibid.*
[111] *Ibid.*

> up. Ibn Khaldun, the father of sociology, found no disciples to continue his work, and Ibn al-Nafis's discovery of the 'lesser' circulation of the blood aroused no interest and had to be made all over again in the West centuries later by Servetus and Harvey. [112]

In a later sections in his chapter, Saunders explains that the reason for the "freezing" of Muslim culture is the "predominance of theology and of an all-embracing religious law, and the absence of a rival secular tradition capable of challenging the dictatorship" of the religious scholars.[113] Other causes are offered by Saunders including the backwardness of the original culture of Islam;[114] the defeat of heretic groups like Isma'ilianism,[115] which – according to Saunders - caused a blow to intellectual liberalism; external invasions[116] and the attacks of al-Ghazali on philosophy.[117] Saunders is applying another term to describe the fate of Islamic science, which is the "freezing" of Muslim culture. Now we have three terms: decline, decadence and freezing.

First, Saunders speaks of decline, decadence and 'freezing' of Islamic culture, but his dominating idea – as the title of his chapter shows – is that of decadence. Second, he does not define the meaning of decadence, but introduces some useful concepts to measure this decadence. Saunders also suggests that decadence must be measured by the accumulation of positive knowledge in a particular society, and not other society. In this context, Saunders asserts that Islamic science

[112] *Ibid.*
[113] *Ibid.*, p.111.
[114] *Ibid.*, p.108
[115] *Ibid.*, p.112
[116] *Ibid.*, p.113.
[117] *Ibid.*, p.121.

decayed because: (1) the stream of creative thinking evaporated, (2) the pursuit of knowledge for its own sake was severely discouraged, and (3) the most promising lines of inquiry were never followed up.

The proposal that the criteria of decadence must be suggested by the achievements of the Islamic civilisation itself is significant, and so are the criteria he uses to establish that. But the most immediate issue that this proposal raises is this: if one is to judge the scientific achievements of Islam by its own standards, then one needs to know these achievements. However, such achievements are only beginning to be discovered, and thus it is only now that a clearer picture of the importance, originality and influence of Islamic science is beginning to emerge.

Any attempt, therefore, to judge the performance of Islamic science without this understanding will be inadequate and could lead to inappropriate results. To substantiate this claim, consider Saunders's ignorance of the achievements of the Maragha astronomers – including al-Tusi and Ibn al-Shatir that emerged in the late 1950s. Knowledge of their contributions to that of Copernicus' heliocentric worldview was already established by the time of the publication of Saunders's work.[118] Saunders's ignorance of this made him arrive at his faulty and generalised conclusion.

Overall, Saunders's` work is a serious attempt to formulate a theory on what happened. It provides some useful concepts to help understand what happened to Islamic science. Compared to Ibn Khaldun's observations, however, he offers a

[118] See, for example, Saliba, "Greek Astronomy and the Medieval Arabic Tradition." *op.cit.,* p.360.

one-dimensional solution to what happened. Saunders's accounts of the history of Islamic science are based on a small number of studies, devoid of up-to-date evidence, which resulted in a theory that is all-inclusive, and reductive.

ALBERTO ELENA

Alberto Elena teaches History of Film at the *Universidad Autónoma de Madrid* and is the Editor of *Secuencias: Revista de Historia del Cine.* He has extensively published on cinemas from the South and his publications include *El cine del Tercer Mundo: diccionario de realizadores* and *Los cines periféricos.* Elena discusses the fate of Islamic science in his 1987 Spanish article "El declive de la ciencia islámica: una reinterpretation."[119] In this article, Elena gives examples of Islamic science that lasted up to the fifteenth century, but then he admits "willingly that the golden age of Islamic science belonged to the past."[120] Elena recognizes that the thorny question of the decline of Islamic science is far from having been settled by any of the classical contributions in this regard.[121] He asserts that there is ample margin for discrepancy amongst historians about the nature, and, particularly, the causes of such decline.[122] But more importantly, Elena believes that it "would not be adequate to use the term decline to refer to this process."[123] Furthermore, he argues, "it would not be appropriate either to talk of stagnation or to affirm that Islamic scientific culture remained frozen,

[119] Alberto Elena, "The decline of Islamic Science: a re-interpretation," *4th International Congress of the History of Arab Science* (Aleppo, Syria, 21-25 April, 1987). A translation by F.Sánchez-Bayo of the original "El declive de la ciencia islámica: una reinterpretation," 1987, pp.1-7.
[120] *Ibid.*, p.2-3
[121] *Ibid.*, p.1.
[122] *Ibid.*
[123] *Ibid.*, p.2-3

though certainly the nature of its progress and rhythm were different."[124] Therefore, Elena offers a 're-interpretation' of the decline thesis.[125]

Elena believes that the idea of stagnation[126] of Islamic Science is "inaccurate." This misnomer, Elena says, is a result of the "'historical' inequity between Europe and the rest of the world," [127] and because the facts available about the real situation of the Islamic world during the sixteenth and seventeenth centuries were insufficient and inadequate.[128] Another reason for this misnomer is the fact that most of the information that came from western sources was neither objective nor free of prejudice.[129]

So what happened to Islamic Science? Elena claims that it underwent a "simple fragmentation" that was "parallel to the political disintegration of Islam towards the end of the Middle Ages and the dawn of modernity."[130] And "this fragmentation could not be seen as stagnation,"[131] and "was far from being frozen."[132] However, Elena does not define the meaning of fragmentation, nor provide useful concepts to explain it.

Overall, Elena's re-interpretation of the fate of Islamic science is important because it for the first time we are witnessing a viewpoint that contravenes the

[124] *Ibid.*, p.3
[125] Elena was surprised to know that I had read his article. When asked whether any one commented on his paper, Elena said that he is not aware of any.
[126] Sayili, *op. cit*, p.408, says that it did not come to " to a standstill during the later centuries, but the pace diminished and slowed down."
[127] Elena, *op.cit.*, p. 5
[128] *Ibid.*, p.5
[129] *Ibid.*
[130] *Ibid.*, p.4.
[131] *Ibid.*
[132] *Ibid.*, p.6.

commonly held notion of decline, and rejects the idea that Islamic science stagnated or froze suggested by earlier scholars. Indeed, this is a substantial departure from previously held beliefs about the fate of Islamic science. Elena's re-interpretation shows some appropriate scholarship because it does not mimic earlier theories and ideas. Unfortunately, however, Elena does not expand on his fragmentation idea by defining it, suggesting useful concepts to explain it, and giving historical evidence to support it. Furthermore, Elena shows unawareness of Ibn Khaldun's work, and comparatively it is one-dimensional and falls short of being complex.

ABDELHAMID SABRA

Abdelhamid Sabra is emeritus professor of the history of Arabic science in Harvard's Department of the History of Science. In 1949 he went on a six-year Egyptian scholarship to study the philosophy of science under Karl Popper. A renowned historian of optics in medieval Islam and in the early modern period, he joined the Harvard faculty in 1972.[133] His work on the history of science first focused on seventeenth-century Europe, later he turned his attention to Islamic science, with studies, editions of primary texts, and translations.

In 1987 article, "The appropriation and subsequent naturalization of Greek science in medieval Islam: A preliminary statement,"[134] Sabra makes specific remarks on

[133] Andrea Early, "Twelve Fas Faculty Members to Retire," *The Harvard University Gazette*. 1996. Available: http://www.news.harvard.edu/gazette/1996/06.13/TwelveFASFacult.html. (11 September 2003).

[134] A.I. Sabra, "The Appropriation and subsequent naturalization of Greek science in medieval Islam: A preliminary statement," *History of Science*, 25, 1987.

what he calls "the problem of decline"[135] of Islamic science. Sabra begins his remarks saying:

> But first let me deliver the disappointing confession that I do not possess a solution to the problem of decline. That the phenomenon in question did in fact occur seems clear to me from comparing levels of scientific production in, say, the fifteenth and eleventh centuries.[136]

Sabra states that the decline of Islamic science occurred because "the philosophers' view of knowledge was replaced by the instrumentalist view proposed by Ghazali," and that science declined "not in the context of [orthodox] opposition (as is usually thought) but in the context of acceptance and assimilation…"[137] In other words, decline set in "when the sciences came to be accepted and practiced only to the extent that they were legitimated by the instrumentalist view."[138] Sabra points out that this suggestion is "not intended as explanation of the phenomenon of decline…It is merely meant as a relevant and possibly illuminating observation that might help in future research by directing our attention in a certain direction rather than other."[139]

It is interesting to note that Sabra's work clearly highlights that he does not accept the suggestion that Islamic science suffered a general (uniform) decline, as is characteristic of the common decline theorists. Sabra explains that:

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135 *Ibid*. p.238.
136 *Ibid.*
137 *Ibid.* p.241.
138 *Ibid.*
139 *Ibid.*

> Difficulties arise when one tries to assign a date to the occurrence, in part because decline is a process that occupies a time-interval, and it is difficult to determine when the process began, but also because we are dealing with a vast geographical area in which not all centers of activity were always in the same phase of development at the same time. Add to this the consideration that decline in one branch of science may coincide with the progress in another. Much specific research must be done before we can produce reliable general description, let alone plausible explanation.[140]

Sabra makes three important points here. (1) It is difficult to assign a date for decline because it is difficult to determine when it began and because the Islamic Empire covered a vast geographical area in which not all centres of scientific activity were in the same phase of development at the same time. (2) Decline in one branch may coincide with progress in another. (3) Much specific research is needed before reliable general conclusions are made. These are important remarks because though Sabra accepts that decline did in fact occur, he seems to reject the conventional theory that stipulates a general decline. In addition, there is a clear suggestion by Sabra that much specific research is needed before reliable general description, let alone plausible explanations, are arrived at. This marks a return to proper scholarship. But it is unfortunate that Sabra shows no indication of awareness of Ibn Khaldun's observations.

In a 2003 publication edited by Sabra and Hogendijk, the question of the fate of Islamic science does not rise. However, they do argue that:

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[140] *Ibid*., pp.238-239.

> The Islamic tradition in the exact sciences continued well into the nineteenth century, and abundant source material is available in the form of unpublished manuscripts in Arabic, Persian, and other languages in libraries all over the world. In the last decades, many researches have worked on the Islamic scientific tradition, and our views of this tradition are rapidly changing as a result of recent discoveries. This process will, hopefully, continue, because important sources have not been identified and studies.[141]

DAVID C. LINDBERG

David C. Lindberg is Hilldale Professor of the History of Science, and Adjunct Member of the Institute for Research in the Humanities, at the University of Wisconsin, Madison. He is the author of more than sixty-five books and articles on topics ranging from Roger Bacon to the relationship between science and Christianity, to the history of optics. In 1992 Lindberg published *The Beginning of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, 600 B.C. to A.D. 1450.* Apparently, "this is the best history of ancient and medieval science that has been written for many years.[142] Lindberg's book "not only reflects more recent research but also is also much easier to read and provides major themes more clearly."[143] Delineating 2000 years of science in all its varieties, Lindberg's book supposedly "provides social, intellectual, and religious background and shows each development or theme in its

[141] Jan P. Hogendijk and Abdelhamid Sabra, *The Enterprise of Science in Islam...*, o*p .cit.,* p.vii.
[142] Eric D. Albright, *Editorial Reviews*. 1992. Reed Business Information, Inc. Available: http://www.amazon.com/exec/obidos/tg/detail/-/0226482308/102-9684130-9657722?v=glance&s=books. (11 September 2003).
[143] *Ibid.*

appropriate historical context."[144]

Though Lindberg's book is meant to "reflect more recent research," his view on what happened to Islamic science is far from accomplishing that. In a sub-heading titled "The decline of Islamic science,"[145] Lindberg states that Islamic science went into a decline "during the thirteenth and fourteenth centuries; by the fifteenth century, little was left."[146] Lindberg then asks, "How did this come about?" To which he answers: "not enough research has been done to permit us to trace these developments with confidence, or to offer a satisfactory explanation, but several causal factors can be identified."[147] The first is that "conservative religious forces"[148] made themselves "increasingly felt,"[149] which at times took the form of "out-right opposition."[150] Other times it was not because of the "extinction of scientific activity,"[151] but "the alteration of its character, by the imposition of a very narrow definition of utility."[152] In his own words:

> Science became naturalised in Islam – losing its alien quality and finally becoming Islamic science, instead of Greek science practiced on Islamic soil – by accepting a greatly restricted handmaiden role. This meant a loss of attention to many problems that had once seemed important.[153]

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[144] *Ibid.*
[145] David C. Lindberg, *The Beginning of Western Science: The European Scientific Tradition in Philosophical, religious, and institutional Context, 600 B.C. to A.D. 1450* (Chicago: The University Chicago Press, 1992), p.180-182.
[146] *Ibid*.
[147] *Ibid*.
[148] *Ibid*.
[149] *Ibid*.
[150] *Ibid*.
[151] *Ibid*.
[152] *Ibid*.
[153] *Ibid*.

Furthermore, there was a decline because of the disappearance of “peace, prosperity and patronage,”[154] all of which are important for a “flourishing scientific enterprise.”[155] This occurred because of “continuous, disastrous warfare among factions and petty states within Islam and attack from without.”[156]

Despite the availability of Ibn Khaldun’s work, and modern findings that prove that some branches of Islamic science flourished during the thirteenth and fourteenth-centuries, Lindberg insists that Islamic science declined. Furthermore, he shows no recognition of the work of previous contemporary scholars like Sabra who, at least, suggested that decline was not uniform. Lindberg’s conclusion is a colossal failure of scholarship. Rather than progressing, Lindberg’s scholarship defines Islamic science by a limited, but highly persistent, bundle of interpretative views with a dominant theme of decline that characterised the work of nineteenth century orientalists. It is a return to poor, and certainly inaccurate, scholarship.

TOBY E. HUFF

Huff is Chancellor Professor of Policy Studies, Centre for Policy Studies, University of Massachusetts. In his book *The Rise of Early Modern Science, Islam, China and the West*,[157] Huff examines the question of why modern science arose only in the west and not in the civilizations of Islam of China, despite the fact that medieval Islam and China were more scientifically advanced. In answering this question, Huff discusses what happened to Islamic science.

[154] *Ibid*., p.181.
[155] *Ibid*.
[156] *Ibid*.
[157] T. E. Huff, *The rise of early modern science* (Cambridge: Cambridge University Press, 1993).

He asserts that the end of the thirteenth century marked the end term of significant cultural and scientific growth in the Islamic world,[158] even though "there were significant scientific events after that, but they were minor in comparison to what was taking place in Europe."[159] He explains that research during the last three decades advanced our understanding of Arabic science, but "these have not shed any light on the puzzle of why Arabic science went into *decline* [emphasis added] after the thirteenth century…In fact, the portrait we now have only heightens the mystery."[160] Huff offers religious, legal, cultural and institutional factors as a cause of decline.

Huff re-emphasizes the idea of decline later in his chapter, using as evidence Sabra's own observation. Confirming the "fact that many Arabic and Persian manuscripts relating to the history of Arabic science are still unread."[161] Huff believes that:

> There is little doubt, as a leading figure [Sabra] in the history of Arab science recently affirmed, "that the phenomena [of scientific decline] did in fact occur" if one compares the "level of scientific production in, say, the fifteenth and eleventh centuries.[162]

[158] *Ibid.*, Footnote 1.
[159] *Ibid*
[160] *Ibid.*, p.54.
[161] *Ibid.*, pp.58-59. For an overview of the many manuscripts that have recently been systematically catalogued see Emile Savage-Smith, "Gleanings from an Arabist's Workshop: Current Trends in the Study of Medieval Islamic Science and Medicine," *Isis*, 79, 1988, pp. 246-72.
[162] *Ibid.*, p.59.

Huff goes on to explain why Arabic-Islamic science failed to give birth to modern science,[163] but he does not elaborate any further on his decline idea. Nevertheless, it is evident from the aforementioned that Huff supports the traditional interpretation of decline of Islamic science, but he asserts that religious, legal, cultural and institutional factors were the cause of decline.

AHMAD Y. AL-HASSAN

Al-Hassan is Professor Emeritus of the Institute for the History of Arabic Science (IHAS), University of Aleppo. He is also a member of the editorial committee of the *Journal of the History of Arabic Science*. He has written a number of books, articles and monographs on Islamic science and technology.[164] One of his articles deals exclusively with "Factors behind the decline of Islamic science after the sixteenth century."[165] In this article, al-Hassan explains the causes of the decline of Islamic science *after* the sixteenth century. Al-Hassan asserts that while Islamic science maintained its leadership between the eighth and the twelfth centuries, it also flourished between the thirteenth and the sixteenth centuries, and maintained its lead, especially in the countries of eastern Islam.[166] To illustrate his point, Al-

[163] For an answer to this question see the work of Al-Hassan, *Islam and the Challenge of Modernity*, *op.cit.,* 358-359.
[164] For example, Ahmad Y. al Hassan and Donald R. Hill, *Islamic Technology: An Illustrated History* (New York: UNESCO and Cambridge University Press, 1987).
[165] Ahmad Y. Al-Hassan, "Factors behind the decline of Islamic science after the sixteenth century," in Sharifah Shifa Al-Attas (ed), *Islam and the challenge of Modernity: Historical and contemporary contexts* (Kuala Lumpur: International Institute of Islamic Thought and Civilisation, 1996).
[166] *Ibid.*, p., 351. This view is supported by modern research in the history of astronomy, medicine, and mathematics in Islam between the eleventh and sixteenth centuries. In astronomy, the work of George Saliba and others support this observation. See for example "Theory and Observation in Islamic Astronomy: The work of Ibn al-Shatir," *Journal for the History of Astronomy*, 18, 1987, pp.35-43; "Arabic Planetary Theories after the eleventh century AD," *Encyclopaedia of The History of Arabic Science*, 1, 1996, pp. 58-127; "Arabic Science Historian George Saliba Rejects Common Explanations of Decline of Science in Islamic World," *Columbia News Video Brief*, July 1 2002. http://www.columbia.edu/cu/news/media/02/georgeSaliba/. In mathematics, see J. Lennart

Hassan discusses briefly the case of the observatory in Islam between the thirteenth and the sixteenth centuries.[167] The Maragha observatory, he explains, was established in 1259 and continued in operation until about 1304.[168] It contained 400,000 books and a good number of distinguished scientists led by the famous Nasr al-Din al-Tusi whose team included leading scientists as Qutb al-Din al-Shirazi, Mu'ayyid al-Din al-Urdi, Muhayi al-Din al-Maghribi and many others. The observatory was an institution of research in astronomy and a scientific academy with excellent opportunities for scientific contact and exchange of ideas.[169] Al-Hassan advocates, with clear evidence, the case that "Islamic achievements in science extended until the middle of the sixteenth century."[170]

It is noteworthy that, unlike scholars who assumed that Islamic science declined sometime between the eleventh and sixteenth centuries, Al-Hassan is searching for answers to the causes of the decline *after* the sixteenth century.[171] Al-Hassan is not echoing assumptions of decline made by many earlier scholars noted above. He is using up-to-date evidence to establish that original research was done after the so-called golden age of Islamic science.

Al-Hassan shows awareness of the recent works in Islamic science, and is the only other scholar (other than von Grunebaum) who shows awareness of Ibn Khaldun's

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Berggren, 'Mathematics and Her Sisters in Medieval Islam: A Selective Review of Works done from 1985 to 1995,' *Historica Mathematica*, 24, 1997; Ahmad Djebbar, 'On Mathematical activity in North Africa since the 9th century,' *AMUCHMA Newsletter*, 15, 1995, pp.3-24. In medicine see for example Emilie Savage-Smith, 'Medicine,' *Encyclopaedia of the History of Arabic Science*, 3, 1996, p.930.

167 Al-Hassan, "Factors behind the decline of Islamic science…" *op.cit.*, pp., 351-352.

168 *Ibid.*

169 *Ibid.*

170 *Ibid.*, p.351.

171 *Ibid.*

work. His representation of Ibn Khaldun's work is, however, problematic. Al-Hassan explains that:

> At the time when scientific communities in Europe were on the increase, all the regions of Islam were witnessing the decline of science and of scientific communities. This phenomena is discussed by Ibn Khaldun in more than one chapter in his *Introduction* (al-Muqaddimah).[172]

Al-Hassan is claiming that Ibn Khaldun discussed the phenomena that *all regions of Islam* witnessed decline in more than one chapter in his *Muqaddimah*. But it was clearly established above that Ibn Khaldun does not arrive at this conclusion. Al-Hassan further states that Ibn Khaldun "discusses the factors which are essential to the flourishing of the sciences and other professions, and the factors which lead to their decline."[173] Again, it was demonstrated above that Ibn Khaldun *does not* discuss factors that lead to *decline*. Ibn Khaldun does use, in some contexts, terms (such as decrease), which could be taken as a local decline. Ibn Khaldun – as was demonstrated earlier – clearly states that different fates awaited Islamic science in different areas at different times. Overall, al-Hassan's work is of high scholarly standards for a number of reasons. He does not mimic earlier scholars by echoing the decline idea. He is shows awareness of Ibn Khaldun's work, though he does not adequately represent it. This is significant because it marks a return to proper scholarship.

[172] *Ibid.,* p. 355.
[173] *Ibid.*

JAMES E. MCCLELLAN III AND HAROLD DORN

James E. McClellan III and Harold Dorn are professors of the history of science at the Stevens Institute of Technology. The World History Association selected their book *Science and Technology in World History*[174] as a winner for its 1999 Book Award, the primary criterion for which is history from a global perspective. In their book, McClellan III and Dorn accept that Islamic science declined, and recognize that "scholars disagree on when the vitality of scientific activity started to decline in the Islamic world."[175]

They accept that "the decline began after the twelfth century, especially in the Western regions."[176] Interestingly, however, they draw the reader's attention to the fact that "others say that important new science continued to be done in the East until the fifteenth and sixteenth centuries."[177] Nevertheless, they cling to the decline notion believing that Islamic science attained heights in "the centuries surrounding the year 1000 and that decline in the creative level of original work eventually set in."[178]

It is astounding to see that the theme of decline has persisted even in this award-winning book. There is a striking relationship between McClellan III and Dorn's theme of decline, and the repetitious, mimetic character, which other orientalists ascribed to the fate of Islamic science. Despite the fact that their work won the

[174] James E. McClellan III and Harold Dorn, *Science and Technology in World History* (Baltimore and London: The Johns Hopkins University Press, 1999).
[175] *Ibid.*, p.113.
[176] *Ibid.*
[177] *Ibid.*
[178] *Ibid.*

1999 award, there is curiously no significant intellectual development in it as far as the fate of Islamic science is concerned; no change in their account from that of classical orientalists' literature; and no understanding of the findings of modern research in the field. McClellan III and Dorn only repeat the old decline notion, and reproduce all the mimetic themes of Orientalism. The stationary nature of their discourse characterises the inadequacy of the scholarship on the topic. Instead of progressing, McClellan III and Dorn retrogress into the time of Renan and his like.

GEORGE SALIBA

Saliba is Professor of Arabic and Islamic Science at Columbia University. He studies the development of scientific ideas from late antiquity till early modern time, with a special focus on the various planetary theories that were developed within the Islamic civilization and the impact of such theories on early European astronomy. Saliba is an expert in the history of Islamic astronomy who has shifted our understanding of its influence on the grand narrative of the history of astronomy, especially its influence on people like Copernicus.

Recently, Saliba rejected the common explanations of the decline of Islamic science, including the claim that scientific inquiry ran afoul with Islamic religious authorities.[179] Saliba believes that the reasons for the decline of Arabic science are

[179] George Saliba, "Arabic Science Historian George Saliba Rejects Common Explanations of Decline of Science in Islamic World," *Columbia News Video Brief*, July 1 2002. http://www.columbia.edu/cu/news/media/02/georgeSaliba/. These arguments can also be found in George Saliba, *The Origin and Development of Arabic Scientific Thought*, [Arabic] (Balamand University, 1998), p.14, pp.163-189, p.190.

a "myth" that needs to be "debunked."[180] He explains that though scientific activity was "tremendous" during the Islamic civilisation, "people have been trying to propose answers to this specific question of what brought it to an end."[181] Saliba says that the "common answer that has been circulating for quite some time now, is to say that Islamic science came in direct conflict with the religious authorities in Islam…that itself caused the decline in Islamic science."[182]

Saliba criticises the argument that al-Ghazali is to blame for this conflict. He asserts that this argument is flawed because of a number of reasons including the fact that "most Muslim scientists who produced the best mathematics, the best astronomy and the best medicine came after al-Ghazali."[183] Saliba adds that people who argue against al-Ghazali try to draw parallels with the Galileo affair and the Catholic Church, where there was a confrontation between religious authorities and scientists.[184] But he says that this parallelism is invalid because "most Islamic scientists were either religious persons themselves, or supported by religious institutions."[185]

He explains that research in Islamic science is still new, and that we need to keep researching scientific activity in the fourteenth, fifteenth, sixteenth and seventeenth centuries to see what happened, and not to "say that simply because there was no scientific activity" then "it went into decline."[186] The latest mathematician that Saliba is working on is Khafri - a contemporary of Copernicus

[180] George Saliba, "Arabic Science Historian George Saliba Rejects …" *op. cit.*
[181] *Ibid.*
[182] *Ibid.*
[183] *Ibid.*
[184] *Ibid.*
[185] *Ibid.*
[186] *Ibid.*

(d.1543) - and a "brilliant astronomer, whose ability to work with the mathematics of his time is unsurpassed, including that of Copernicus."[187] Saliba explains:

> If I take those two men, one of them is living in what is modern day Iran, in a city near Asfahan, and the Copernicus living in Poland, if I take their production right now and compare their mathematics you can easily see the Iranian astronomer by the name of Khafri, could use mathematics much more fluently, and much more competently, than Copernicus could do... If that is the case with this sixteenth century astronomer then God knows what there is in the seventeenth century because I have not reached the seventeenth century, yet what is there in the eighteenth century.[188]

Finally, Saliba claims that "sure there was a decline,"[189] however "which science has declined, at what time, under what conditions, what political, economic, social reasons?"[190] This decline, however, was not the result of al-Ghazali's attack on philosophy, as is commonly believed, but a result of the industrial leap forward that Europe achieved particularly after the discovery of America by Columbus[191](in 1485). From that time onwards, Saliba explains, the Islamic world seems to be at a race with Europe, and not only did it fail to catch up with it, but the gap is ever widening day after day, and year after year.[192] Saliba also remarks that there was no age of decline; rather, the Islamic world lost the race with the

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[187] *Ibid.*
[188] *Ibid.*
[189] *Ibid.,* and Saliba, *The Origin and Development of Arabic Scientific Thought*, *op. cit.*, p.187.
[190] *Ibid.*
[191] Saliba, *The Origin and Development of Arabic Scientific Thought*, *op. cit.*, p.187
[192] *Ibid.*

European civilisations, in which the loser seemed to be in decline.[193] Here, Saliba is raising two important points pertaining to decline. (1) One needs to investigate which branch of Islamic science declined and under what societal conditions. (2) Whether decline occurred only when compared to European achievements, and after the discovery of America. Saliba rejects the notion of decline based on substantial recent evidence and argues that the best mathematics, medicine and astronomy came after the supposed period of decline.

Saliba recognises that the level of scientific activity after the sixteenth century must have dropped compared to previous periods, and thus admits that a decline did happen after the sixteenth century. But he clearly asserts that it is still premature to conclude which science has declined, at what time, under what political, economic, and social conditions. Saliba's remarks reinforce Sabra's argument that Islamic science did not suffer a uniform decline, and that much specific research is needed before reliable general description, let alone plausible explanation, can be made.

Based on his understanding of the development of astronomy he rejects the belief that Islamic science declined in the period under question. Saliba argues that the best mathematics, medicine and astronomy came after the supposed period of decline. Saliba recognises that the level of scientific activity after the sixteenth century must have dropped compared to previous periods, but unlike previous scholars (except Sabra and al-Hassan) he clearly asserts that it is still premature to conclude which science has declined, at what time, under what conditions, what

[193] *Ibid*

political, economic, social reasons. This means that any overall generalisation about the fate of Islamic science cannot be possibly correct.

Saliba's work also highlights similar observations made by Sabra and Sayili: that Islamic science could not have declined uniformly in all branches and locations. Furthermore, Saliba's remarks reinforce Sabra's recommendation that we need to have special separate monographs about different branches of science, in different regions and periods, before we can produce reliable general description, let alone plausible explanation about the fate of Islamic science. While Saliba's views are of high scholarly standards, it is unfortunate, however, that he showed no awareness of Ibn Khaldun's theory, which fits well with his own recommendations.

OTHERS IN BRIEF

In 1976, Wickens[194] mentioned that Islamic science had declined but felt that 'stagnation' is a more adequate description of what happened. In a 1988 paper, Qadir explained that Islamic science had declined and became extinct among Muslims because of their adoption of Greek philosophy.[195] In 1992, Hoodbhoy stated that Islamic science had declined because of the efforts of al-Ghazali (d.1111) – and the Asharite doctrine.[196] In 1988, Ragab[197] and, in 1993 Ahmad[198]

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[194] G. M. Wickens, "The Middle East as world centre of science and medicine," in R. M Savory (ed), *Introduction to Islamic Civilisation* (Cambridge: Cambridge University Press, 1976), p.118.

[195] C.A. Qadir, *Philosophy and science in the Islamic world* (London: Croom Helm Ltd., 1988) pp.124-125.

[196] P. Hoodbhoy, *Islam and Science: Religious Orthodoxy and the battle for Rationality* (Pakistan: Zed Books, 1992), p.2. According to Hoodbhoy, Al-Ghazali's attack on Aristotelian Philosophy strengthened the "fatalistic" Asharite doctrine "that the apparent cause-and–effect of natural science is only an apparent relationship with God being the actual cause." Thus, this "anti-science" dogma "led to a withering away of its [Islamic] scientific spirit." This doctrine, however,

suggest that Islamic science had declined. In 1993, Hudgson adopted a cautionary attitude and declared, "we must await further investigation before we can decide whether, even in the special field of natural science, there was any actual decadence."[199] In 1996, Turner accepted decline as an answer, but claimed that "the reasons why the vigour of scientific inquiry apparently atrophied amongst Islam's scholars" [200] remains a major challenge to historians. In 1996, Robinson asked: Why did advances in Islamic sciences "peter out?"[201]

SUMMARY AND CONCLUSION

The aim of this chapter was to present a comprehensive review of scholarship on the fate of Islamic science from Ibn Khaldun to the present. This chapter reviewed some major theoretical statements regarding the fate of Islamic science, and found that, roughly, they belong to four groups:

(1) Ibn Khaldun's multi-dimensional theory

(2) The decline theory

(3) Non-decline ideas – these include the ideas that Islamic science "decayed,"

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is "not a scientific theory, but a metaphysical statement for the accommodation of miracles, which, by definition, are outside the scope of natural science." It need not impede the progress of natural science. Al-Ghazali, for example, argued against Galen's assertion of the eternity of the world using scientific arguments.

[197] I. Ragab, *Islam, Fundamentalism, and Development* (1988). Professor, Department of Sociology & Anthropology Kulliyyah of Islamic Revealed Knowledge & Human Sciences International Islamic University Malaysia. http://msanews.mynet.net/Scholars/Ragab/develop.html

[198] I. A. Ahmad, "Islam and Science: Religious Orthodoxy and the Battle for Rationality" (book reviews), *Arab Studies Quarterly*, 15.3, 1993, p.133.

[199] Marshall G. S. Hodgson, *Rethinking World History: Essays on Islam, Europe and world history* (Cambridge: Cambridge University Press, 1993), p.104.

[200] Turner, *op.cit* p.205

[201] F. Robinson, "Knowledge, its Transmission and the Making of Muslim Societies," in Robinson, F. (ed.), *The Cambridge Illustrated History of the Islamic World*. (London: Cambridge University Press, 1996.)

"froze," "fragmented," or came to a "stand-still."

(4) That Islamic science flourished up to the sixteenth century.

The chapter has demonstrated that there are diverse opinions regarding the fate of Islamic science, but the idea that Islamic science declined after the eleventh century has gained a wide currency, and may have been established as the preferred scholarly paradigm. Other terms were also used to describe what happened, such as: "decadence," "stagnation," "fragmentation," "standstill," and that Islamic science "froze." However, these views were infrequently used and did not replace the dominant decline concept. The chapter also revealed that even though recent evidence challenges the decline theory, it persisted in the work of many contemporary scholars. More importantly, the chapter has also demonstrated that six centuries ago, Ibn Khaldun provided a sophisticated and complex theory regarding what happened to Islamic science. After Ibn Khaldun, there was a centuries long gap in which even excellent scholars totally ignored his theory, and merely used simplistic and dismissive terms regarding what happened. These terms were defined by a limited, but highly persistent, bundle of interpretative views with a dominant theme of decline. In addition, many scholars failed to build on the work of others; they ignored major pieces of evidence; and, in most cases, they were not trying to discern what happened to Islamic science but were referring to the subject as part of another project.

One key aspect of the explanation for the failure to provide complex theories and ideas regarding what happened must consist of a number of hypotheses about the processes occurring at various junctures in the production, reception, assessment, and dissemination of scholarly knowledge. Chapter Three demonstrated that one of the assumptions underlying adequate scholarship is that a systematic effort allows faulty theories based on mistaken assumptions, or unsustained predictions, to be either "repaired" or "abandoned."[202] Certainly, a thoughtful reading of Ibn Khaldun's theory, or original texts on Islamic science, would have forced rejection, or alteration, of all single-dimensional claims, including the much vouched for decline theory. Adequate research would have shown the falsity of the idea that Islamic science failed to flourish after the eleventh century. Inadequate research, however, allowed simplistic claims to persist for centuries, and delayed their rejection by scholars like Saliba.

There were some scholars who researched original sources. But, contrary to evidence, they clung to the handed-down theory of decline (like Sarton, Sayili, Huff, Hoodbhoy, Qadir and Lindberg). In these cases, two processes may have been involved: a simple reworking of the old mythology, and an easy acceptance of the probable (because it is so often repeated) framework even in the face of contrary evidence. Sayili and Huff, for example, provided new evidence to dispel the notion of decline, but this did not change previous assumptions, the handed-down claim of decline remained in their views as valid as ever.

Others disregarded available evidence that could have easily been applied to dispel many simplistic notions. Hitti proposed his single-faceted and simplistic claim in 1968; Saunders in 1977; Elena in 1987; and Qadir in 1988. In 1992 Lindbergh still believed that Islamic science declined "during the thirteenth and

[202] Hamilton, *op.cit*. p.xii.

fourteenth centuries: by the fifteenth century, little was left."[203] In 1999 McClellan III and Dorn asserted, "others say that important new science continued to be done in the East until the fifteenth and sixteenth centuries,"[204] but Islamic science reached its heights in "the centuries surrounding the year 1000 and that decline in the creative level of original work eventually set in."[205] Considering the availability of evidence by their time, such conclusions are preposterous.

More adequate views began to emerge in the more recent works of scholars like al-Hassan, Sabra and Saliba. Based on substantial evidence, these scholars began to reject, or doubt, the conventional idea that Islamic science suffered a uniform fate. Though they did not offer alternative theories, some of them were cautious not to draw overall conclusions about what happened (particularly al-Hassan and Saliba). They recommended (al-Hassan, Sabra and Saliba) that we study different fields of Islamic science in different contextual settings before overall conclusion are drawn.

The inadequate scholarship of research that persisted for a long time, then, leads to a certain conclusion. With the exception of scholars like al-Hassan Sabra, and Saliba, the claims made regarding the fate of Islamic science are at best a set of hypotheses with rather doubtful empirical foundations. This highlights a serious problem in the scholarship: For a long time, these simplistic schemes were sustained without any serious review of sources or, at minimum, without any successful challenge to the widespread agreement about facts or interpretations

[203] Lindberg, *The Beginning of Western Science... op.cit*., p.180.
[204] McClellan III and Dorn, *Science and Technology in World History*, *op.cit.,* p.113.
[205] *Ibid.*

that were mistaken (as in the decline theory). If undertaken, research would have yielded some striking instances of non-support for one dimensional claims, particularly the long held decline theory and, on the basis of what it is now know, an absence of compelling supporting evidence.

The thesis shall now turn to a practical aim: to apply the various theoretical claims made here to four case studies from the history of Islamic science in order to throw further light on practical problems in the scholarship under question. These case studies demonstrate that, contrary to the beliefs of most scholars, Islamic science persisted at a higher level of excellence, in far more areas, and for a far longer time than has previously been acknowledged, and that it suffered differing fates in different areas.

5

THE FATE OF ISLAMIC MATHEMATICS IN THE MAGHRIB BETWEEN THE ELEVENTH AND SIXTEENTH CENTURIES

INTRODUCTION

Chapter Four reviewed some major theoretical statements regarding the fate of Islamic science and found that, roughly, they belong to four groups. Ibn Khaldun's multi-dimensional theory, the decline theory, non-decline ideas, and that Islamic science flourished up to the sixteenth century. It demonstrated that after Ibn Khaldun there was a centuries-long gap, in which even excellent historians simply used simplistic and dismissive terms to describe what had happened. The next four chapters constitute the practical aim of the thesis, where four case studies of distinct branches of Islamic science, belonging to different geographical areas, will be examined. The aim is to see how far they fit into the theoretical claims established in Chapter Four. All these case studies are drawn from the context of modern studies in the history of Islamic science. This chapter constitutes the first of these case studies. It examines the fate of mathematics in the Maghrib (northwest Africa) to see how far it fits into the four theoretical statements established in Chapter Four.

The growing amount of modern research on the history of mathematics in the Maghrib (and Al-Andalus) has shifted our understanding of this Islamic science tradition. According to Berggren,[1] most important amongst these is the research conducted by scholars like Ahmed Djebbar, Jan P. Hogendijk, and Aballagh. Of these, Djebbar's most recent research is valuable, because it sheds new light on the development of mathematical activity in northwest Africa from the ninth century to the sixteenth-century. In a 2003 chapter entitled, "A Panorama of Research on the History of Mathematics in al-Andalus and the Maghrib between the Ninth and Sixteenth Centuries,"[2] Djebbar offers a unique survey of the research done by modern historians between 1834 and 1980 on the history of medieval mathematics and astronomy in those geographical areas. The survey shows the progress that has been made in the last decades in our understanding of medieval mathematics in the Maghrib.

For the purposes of this chapter, Djebbar's 1995 paper, "On Mathematical activity in North Africa since the 9th Century,"[3] is used because it makes a clear and up-to-date sketch of the development of mathematical activities in northwest Africa. Because modern research in this filed is very limited, this chapter will depend heavily on this work of Djebbar whose main research interests are in the history of Arabic mathematics in North African and Muslim Spain.

This chapter is organised in the following manner. Section one gives a brief description of Islamic mathematics in the Maghrib during the tenth and eleventh-

[1] J. Lennart Berggren, 'Mathematics and Her Sisters in Medieval Islam: A Selective Review of Works done from 1985 to 1995,' *Historica Mathematica*, 24, 1997, p.408.
[2] Ahmed Djebbar, "A Panorama of Research on the History of Mathematics in Al-Andalus and the Maghrib between the Ninth and Sixteenth Centuries," in Jan P. Hogendijk and Abdelhamid I. Sabra (eds), *The Enterprise of Science in Islam: New Perspectives* (Cambridge: The MIT Press, 2003), pp.309-50.
[3] Ahmad Djebbar, 'On Mathematical activity in North Africa since the 9th century,' *AMUCHMA Newsletter*, 15, 1995, pp.3-24. Printed by the African Mathematical union.

centuries. Section two describes mathematical activities, and the work of some of the most important mathematician, between the twelfth and fourteenth-centuries. Section three describes mathematical activities after the fifteenth century. The last section offers concluding remarks about the fate of mathematics in the Maghrib between the eleventh and sixteenth-centuries.

1. MATHEMATICS IN THE MAGHRIB DURING THE TENTH AND ELEVENTH-CENTURIES

Djebbar explains that little is known of the mathematical activities in the Maghrib during the tenth century.[4] The patronage that was started by the Aghlabid dynasty seems to have continued, which profited Mathematics and Astronomy.[5] However, no scientific documents have survived, which could permit conclusions to be made about the contents of what was produced or taught at that time.[6] More is known about the mathematical activities of the eleventh century, though "knowledge remains still very fragmentary."[7]

It is now known that certain scholars of this period published works in Mathematics and Astronomy, but such works have not reached us.[8] It is known that such scholars occupied themselves with Geometry and Arithmetic, but "we are still ignorant of their links with the different scientific foyers of their epoch and, in particular, about the circulation and the impact of their mathematical

[4] *Ibid.*
[5] *Ibid*
[6] *Ibid*
[7] *Ibid*
[8] *Ibid*

writings in the cities of the Maghrib."[9] Therefore, it is not possible to comment on the fate of Mathematics in this period, simply because knowledge on this field remains limited due to the absence of sufficient materials.

2. Mathematics During The Twelfth, Thirteenth And Fourteenth-Centuries

The cultural and scientific history of the twelfth and thirteenth centuries still remains a vast unexplored field.[10] However, there is sufficient evidence based on modern research to show the extent of mathematical activities in the Maghrib. This is true particularly of the works of five mathematicians, including: al-Qurashi (d. 1184), al-Hassar (Twelfth century), Ibn al-Yasamin (d. 1204), Ibn Mun'im (d. 1228) and Ibn al-Banna (1256-1321).[11] Djebbar informs us that these five mathematicians belong to the Maghrib for a number of reasons. Firstly, all of them seem to have lived there and published certain mathematical works, even if some of them may have been educated, totally or partially, in a city of Muslim Spain.[12] Secondly, according to modern research in the field, these are the first mathematicians from North Africa some of whose work has been discovered, which allows certain conclusions to be made about mathematical activities in this region.[13]

[9] *Ibid*
[10] *Ibid*
[11] *Ibid*., p.7, and Berggren o*p.cit*., p.425.
[12] *Ibid.*
[13] *Ibid.*

However, while modern research in this field is not complete, an examination of the works of each of these would allow us, perhaps, to gauge the extent of mathematical activities in the Maghrib between the twelfth and sixteenth centuries.

The Mathematical Works of Al-Qurashi (d. 1184)

Known as Abul-Qasim al-Qurashi of Bougie[14] (d. 1184), he was born and died in Spain, but Djebbar's recent studies indicate that most of his work was done in the Maghrib.[15] He was considered a specialist in Algebra and in the science of inheritance.[16] In Algebra, al-Qurashi is known for his commentary on the book of the great Egyptian mathematician Abu Kamil (d. 930).[17] This commentary has not yet been recovered.[18] Ibn Khaldun was aware of this treatise and considered it one of the best treaties written on the book of Abu Kamil.[19]

Recent discoveries of fragments in the book of Ibn Zakariya (d.1404) conclude: "This work of al-Qurashi was not a simple commentary on a famous treatise of algebra of its time."[20] Here, "new elements" are found starting at the level of

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[14] Franz Rosenthal, *The Muqaddimah: An Introduction to History* (New York: Pantheon Books, 1958), vol.3, p.126, footnote no. 637.
[15] Djebbar, o*p.cit*., p.7.
[16] *Ibid*., and Rosenthal, o*p.cit*., p. 126.
[17] *Ibid*.
Abu Kamil was active around 901. He wrote *Algebra* as a commentary on that of al-Khawarizmi. The Muslim writer al-Karaji in the late tenth century and the Italian Leonardo of Pisa (Fibonacci) made considerable use of Abu Kamil's examples. Berggren, 1986, o*p. cit*., p.108.
[18] *Ibid*
[19] *Ibid.*
[20] *Ibid*

presentation.[21] This means that the stream of creative thinking did not evaporate, but was developing.

Al-Qurashi "starts by presenting the objects and the operations of Algebra before explaining the solution of the canonical equations followed by the demonstration of the existence of the solutions of these equations."[22] This distinguishes al-Qurashi from his "predecessors in the classification of the six canonical equations and in their demonstrations."[23] Ibn Zakariya' confirms that al-Qurashi's work was studied and taught in the Maghrib until the fourteenth century.[24] Furthermore, scholars like Djebbar speculate that the importance of this book led Ibn al-Banna to write, some decades later, his book *Kitab al-usool wal-muqaddimat fi'l-jabr* (Book of the foundations and of the preliminaries in Algebra).[25]

Al-Qurashi is also known to having elaborated a new method in the domain of inheritance, "based on the decomposition of the numbers in prime factors in order to reduce the fractions that intervene in the distribution of a given inheritance to the same denominator."[26] A number of mathematicians appreciated his method and wrote handbooks explaining it and showed its usefulness through the presentation of concrete problems of inheritance.[27]

[21] *Ibid*
[22] *Ibid*
[23] *Ibid*.
[24] *Ibid*
[25] *Ibid*., p.8.
[26] *Ibid*., p.8. See also M. Zerrouki, 'Abul-Qasim al-Qurashi: haytuh wa mu'allafa tuh ar-riyyadiyya,' [Abu l-Qasim al-Qurashi: his life and his mathematical writings]. *Cahier du Séminaire Ibn al-Haytham* n° 5. Alger, E.N.S., 1995, pp. 10-19.
[27] *Ibid.*

THE MATHEMATICAL WORKS OF AL-HASSAR (TWELFTH CENTURY)

According to Djebbar, no precise element concerning al-Hassar's origin and dates of birth and death exists. However, with al-Hassar, writes Berggren, "we have entered what was at one time supposed to be the period of decline in Islamic science."[28] Two writings of al-Hassar have survived, *Kitab al-bayan wa t-tadhkir* (Book of proof and recall), and *al-Kitab al-kamil fi fan al-'adad* (The complete book on the art of number).[29]

The first book is important for three reasons. First, this manual remains the most ancient work of calculation representing simultaneously the tradition of the Maghrib and that of Moslem Spain.[30] Second, this is the first book wherein a symbolic writing of fractions is found, which "utilises the horizontal bar and the dust ciphers i.e. the ancestors of the digits that we use today (and which are, for certain among them, almost identical to ours)"[31] Third, as Moses Ibn Tibbon realised in 1271, this handbook is the only Maghribian work of calculation known to have circulated in the scientific foyers of south Europe in the form of a Hebrew translation.[32]

[28] Berggren, o*p.cit*., p.425.
[29] Djebbar, o*p. cit*., p.8.
[30] *Ibid.*.
[31] *Ibid.*
Burton says: "The Arabs at first copied the Hindu notation, but later improved on it by inserting a horizontal bar between the two numbers." See David M. Burton, *The History of Mathematics - An Introduction* (Iowa: William C. Brown, 1988.)
Fibonacci (c.1175-1250) was the first European mathematician to use the fraction bar as it is used today. He followed the Arab practice of placing the fraction to the left of the integer. F. Cajori, *A History of Mathematical Notations*, Vol.1 (Illinois: The Open Court Publishing Co., 1928-1929), p. 311.
[32] *Ibid.*

The second book does not provide much information on the work of al-Hassar simply because only its first part was recovered and identified in 1986.[33] The second part of the work, has not yet been recovered, "is dedicated to operations on fractions, to the summation of the different categories of whole numbers and to the exposition of the algorithms that allow for the calculation of perfect, deficient, abundant, and amicable numbers."[34]

THE MATHEMATICAL WORKS OF IBN AL-YASAMIN (D. 1204)

In the light of recent research, Ibn al-Yasamin is better known than al-Qurashi and al-Hassar.[35] Probably, he perfected himself in mathematics in Seville before returning to the Maghrib.[36] Ibn al-Yasamin was known, for a long time, for his minor work of 52 lines (Poem on Algebra).[37] Possibly, this incited him to write two other works: one deals with the roots of numbers, and the other summarizes the method of false position.[38] A much more important work, both at the quantitative and the qualitative level, was written by Ibn al-Yasamin[39] The nature of the materials and mathematical instruments of this book "make it an *original*[40] book and certainly also significant to this period of transition where three mathematical practices run in parallel before flowing together into the same stream: that of the East, of Moslem Spain and of the Maghrib."[41]

[33] *Ibid.*
[34] *Ibid.*
[35] *Ibid.*, p.9.
[36] *Ibid.*
[37] *Ibid*.
[38] *Ibid.*
[39] *Ibid.*
[40] Emphasis added.
[41] *Ibid*.

According to Djebbar this is also the oldest book that contains "both the objects and the operations of Algebra, which permit the writing and solution of equations or abstract manipulation of polynomials." [42] The symbolism of Ibn al-Yasamin are found in the works of mathematicians of the fourteenth and fifteenth centuries, which, if can be confirmed by other testimonies, would mean that symbolic practice is much older than once believed.[43]

The Mathematical Works of Ahmad Ibn Mun'im (d. 1228)

Ahmad Ibn Mun'im was considered one of the best specialists in Geometry and Number Theory. In Mathematics, Ibn Mun'im published numerous works, dealing with such diverse subjects as Euclidean Geometry, Calculation, construction of magic squares, Number Theory and Combinatorics.[44] However, the book on *Fiqh al-hisab* (*The science of Calculation*) is the only one that has survived.[45] The contents of this book are diverse and rich.

Ibn Mun'im's work are particularly important because of their reference to the work of other mathematicians like Ibn Sayyid, who was an important geometer of the eleventh century.[46] And of the work of scholars like al-Mu'taman (d. 1085), whose book, *The book of perfection*, is dedicated to Geometry and with a first chapter on Number theory.[47] The importance of this work is shown in the fact

[42] *Ibid*.
[43] *Ibid.,* p.10.
[44] *Ibid*., p.11.
[45] *Ibid*.
[46] *Ibid.*
[47] *Ibid.*

that certain chapters continued to be studied in some parts of the Maghrib during the thirteenth and fourteenth centuries, particularly by Ibn al-Banna.[48]

Ibn Mun'im's work, *Fiqh al-hisab*, can be considered original because, "in it one finds new trends and results whose origin is perhaps to be found in the activities of the Almohad capital or in the preoccupations of its intellectual environment."[49]

> More precisely, one discovers in it, alongside the classical chapters on arithmetical operations, others like one on the study of figurate numbers, one on the determination of amicable numbers and, in particular, one on enumeration of all words of a language utilising a given alphabet. It is indeed here that Ibn Mun'im's most important contribution lies. He does not explain the reasons that motivated him to the study of this type of problem and which led him to dedicate a chapter of 19 pages that contains the important combinatorial propositions and trends which will be rediscovered, in Europe, only in the 16th and 17th century, in particular by Cardano (d. 1576), Mersenne (d. 1648), Frénicle (d.1675) and Pascal (d.1662).[50]

Furthermore, the influence of Ibn Mun'im is seen in the work of Ibn al-Banna (*Advertisement to the intelligentsia*), which evokes explicitly one of the methods

[48] *Ibid.*
[49] *Ibid.*
[50] *Ibid.*

of Ibn Mun'im, "that of the arithmetic triangle, to enumerate all words which are possible to pronounce when one utilises the 28 letters of the Arab alphabet."[51]

It is now known that al-Qurashi, al-Hassar, Ibn al-Yasamin and Ibn Mun'im flourished in the Maghrib during the twelfth and thirteenth centuries. Djebbar claims, however, that it is possible that these are not the only mathematicians.[52] In fact, for the same period, other mathematicians, sometimes as important as those mentioned, also flourished. But they are not known because their mathematical writings "have not come to us and we cannot speculate on their contents. At most one may judge their importance from certain quotations of their writings or from certain testimonies on their stature as men of science.[53]

THE MATHEMATICAL WORKS OF IBN AL-BANNA (1256-1321)

According to Djebbar, in the light of the bibliographical testimonies and manuscripts that survived, mathematical production in the fourteenth century is distinguished for its quantitative and qualitative importance, which influenced the teaching of mathematics in the whole of North Africa and sometimes sub-Saharan regions.[54] However:

> …the majority of the mathematical production of this century is a return, in the form of commentaries, summaries or developments, to a part of

[51] *Ibid.*
[52] *Ibid.*, p.12.
[53] *Ibid.*
[54] *Ibid.*, p.13.

> what had already been discovered or assimilated during the preceding centuries. New contributions are indeed exceptional.[55]

Ibn al-Banna is amongst the most important mathematicians that appeared during the fourteenth-century. Ibn al-Banna may be considered, "one of the last innovators of the great Arab mathematical tradition,"[56] and based on the work of commentary, "one of the initiators of a new tradition of teaching of mathematics."[57]

Ibn al-Banna produced about eighty-two[58] works in mathematics. He seems to have been the first to consider a fraction as a ratio between two numbers.[59] Some of Ibn al-Banna's most famous works include, *Talkhis amal al-hisab* (Summary of Arithmetical Operations) and *Raf‘ al-Hijab* (Lifting of the Veil), in which he introduces some mathematical notation that has led some to believe that algebraic symbolism was first developed in Islam by Ibn al-Banna and al-Qalasadi.[60] More recent research shows that Ibn al-Banna had influenced the work of al-Qalasadi whose use of an algebraic symbolism was already employed by a number of eastern mathematicians, and in the Maghrib by the Moroccan Ya‘qub b. Ayyub (c. 1350) and the Algerian Ibn Qunfudh (d. 1407).[61]

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[55] *Ibid*.
[56] *Ibid*.
[57] *Ibid*.
[58] H. P. J. Renaud, *Ibn al-Banna de Marrakech, sufi et mathématicien*, Hesperis, 25, 1938.
[59] M. Zarruqi, fractions in the Morroccan mathematical tradition between 12th and 15th centuries A.D. as found in anonymous manuscripts (Arabic), in *Deuxiéme Colloque Maghribin sur l'Histoire des Mathématiques Arabes* (Tunis 1990), A97-A109.
[60] G. Arrigh, 'Review of some mathematical symbols,' (Italian) *Physics – Riv. Internaz. Storia Sci*., 27, 1-2, 1985, pp.163-179.
[61] Juan Vernet and Julio Samso, "Development of Arabic Science in Andalusia," in Roshdi Rashed (ed) *Encyclopaedia of the history of Arabic Sciences*, *op.cit*.,1, 1996, p.272. Also, see *Dictionary of Scientific Biography*, XI, pp.229-30.

Ibn al-Banna is the last Maghribian mathematician who was involved in original research, which tackled new problems, with original solutions or advanced with new ideas.[62] His most important original contributions in mathematics are "the announcement and the demonstration, for the first time to our knowledge, of the formula of factorials giving the combinations of n letters of a given alphabet taken p at a time, without utilising the arithmetic triangle, a result that will be established once again by Pascal three centuries later."[63] As Rashed points out:

> In our opinion, there is something more fundamental than [the Pascal triangle] results; it is precisely the combinatorial appearance of ibn al-Banna's exposition, together with the relation he partially establishes between polygonal numbers and combinations. It concern, in the first place, triangular numbers and combinations of p objects in twos, and then polygonal numbers of order 4 and combinations of p objects in threes.[64]

In recent works by Saidan, it is established that "Ibn al-Banna, or his predecessors in the West, accepted fully the idea of the general common fraction a/b and set it up as $\frac{a}{b}$, but wrote a quantity like $4\frac{3}{4}$ as $\frac{3}{4}4$ ignoring the place-value arrangement."[65]

[62] *Ibid*., p.13.
[63] *Ibid.,* p.12.
[64] R. Rashed, *The development of Arabic mathematics: Between arithmetic and algebra* (London, 1984).
[65] Ahmad S. Saidan, "Numeration and Arithmetic," in Roshdi Rashed (ed), *Encyclopaedia of the history of Arabic Sciences*, *op.cit*., 2, 1996, pp. 339-340.

Furthermore, Ibn al-Banna "established, as far as possible, the relations that exist between the figurate numbers of Nicomachus, the combinations of n objects taken p at a time and the sums of certain progressions of whole numbers."[66] Also, Ibn al-Banna:

> Utilises the techniques or the trends of combinatorial type to solve certain problems outside mathematics and which lead to enumerations with constraints, as for example the determination of the number of possible readings of a given phrase, taking into account the rules of the Arab grammar, or of the number of prayers that a Moslem has to say to compensate for the forgetting of a certain number among them.[67]

Ibn al-Banna's mathematical contribution started a tradition of commentaries that extended to the different regions of North Africa, Egypt, and Muslim Spain.[68] For example, more than fifteen "relatively important"[69] works were dedicated to the "explanation or to the development, and sometimes even to the critique, of his little manual *at-Talkhis*."[70] While these commentaries have not been subjected to a complete analysis,[71] a comparative study of their contents "reveal both quantitative and qualitative differences."[72]

[66] Djebbar, o*p. cit*., p.12.
[67] *Ibid.*
[68] *Ibid.,* p.15.
[69] *Ibid.*
[70] *Ibid.*
[71] *Ibid.*
[72] *Ibid.*

Quantitatively, there are short commentaries that are only dedicated to explaining definitions and algorithms[73] with no original contributions. But also, there are other commentaries that sometimes severely criticize Ibn al-Banna, and abandon the themes dealt with by him and others.[74] Qualitatively, some commentaries are distinguished by the:

> …Utilisation or not of arithmetical and algebraic symbolism and by the recourse or not to the explanation or to the critique of certain definitions, to the demonstration of the propositions evoked by Ibn al-Banna and to the justification of the validity of the algorithms that he exposed.[75]

The detailed analysis of the most important chapters of these commentaries has led some scholars, such as Djebbar, to a number of conclusions about mathematics during the fourteenth-century. First, the *level* of the mathematics during the fourteenth century "is not lower than that of the previous period."[76] However, certain themes that had been taught from the tenth century are not recovered in this period.[77] This was already perceptible in the work of Ibn al-Banna and it was only to extend from the fourteenth century onwards.[78] Second, no new contributions were made in these commentaries, "either on the theoretical plane or at the level of the applications of earlier ideas and techniques."[79] For example, the use of symbolism, which appeared in the writings of al-Hassar and

[73] *Ibid.*
[74] *Ibid.*
[75] *Ibid.*
[76] *Ibid.*
[77] "Such as the extraction of the approximate cubic root of a number, or the computation of new pairs of amicable numbers." *Ibid.*
[78] *Ibid.*
[79] *Ibid.*

Ibn al-Yasamin, was "frozen or curbed" during the entire thirteenth century and the first half of the fourteenth century.[80] Whatever the cause, Djebbar notes, "difficult Maghribian works, or those having that reputation, are left by the commentators or are only used to better clarify the explanation of this or that passage of the *Talkhis* of Ibn al-Banna."[81]

Furthermore, from this period onwards, "a change in the scientific production of the Moslem West" is witnessed, "even at the level of references"[82] to mathematical works. While Euclid, Nicomachus and al-Khawarizmi were still referred to, but mathematicians of the Maghrib or of Muslim Spain were frequently cited in the commentaries of the fourteenth and fifteenth-centuries.[83]

3. MATHEMATICS AFTER THE FIFTEENTH CENTURY

According to Djebbar, more than 150 mathematicians (or teachers of mathematics) lived in the Maghrib after the fifteenth century.[84] Metrical Geometry, Calculation, magical squares and the distribution of inheritance were the subject matter of mathematics.[85]

Djebbar informs us that in the light of the texts that have been studied, it can be concluded: "The content of this production differs from the earlier mathematical

[80] *Ibid.*, p.16.
[81] *Ibid.*, p.16-17.
[82] *Ibid.*
[83] *Ibid.*
[84] *Ibid.*, p.17.
[85] *Ibid.*

writings in form and standard."[86] One finds poems, glosses or commentaries, and summaries.[87] Furthermore, the level of these mathematical works is "lower than that of the works"[88] of the fifteenth century, which in itself is "much less rich, with respect to ideas and techniques,"[89] than the works of the thirteenth and fourteenth centuries.[90] Thus, quantity of mathematicians during this period was not a problem, but the quality was much inferior to the previous centuries.

SUMMARY AND CONCLUSION

The aim of this chapter has been to examine the fate of mathematics in the Maghrib between the eleventh and sixteenth-centuries to see how far it fits with the four theoretical claims. The chapter has demonstrated that, based on the most recent work of Djebbar, mathematics in the Maghrib did not "decline," "freeze," "stagnate," or suffer any single-faceted fate after the eleventh century. In fact, there was a rise in mathematical activities in the Maghrib after the eleventh century. According to Djebbar, the twelfth, thirteenth and fourteenth centuries marked the peak period of original works in mathematics in the Maghrib. After the fourteenth century, a reduction in the quality (not quantity) of mathematics became noticeable, where certain themes that had been taught from the tenth century were not recovered in this period. This was already perceptible in the work of Ibn al-Banna, and it was only to extend from the fourteenth century onwards.

[86] *Ibid.*
[87] *Ibid*
[88] *Ibid*
[89] *Ibid*
[90] *Ibid*

The chapter also shows that, according to Djebbar, termination of research in mathematics set in after the fifteenth century, and research in mathematics simply stopped. Due to this, original work *ceased* and publishing of books – with nothing original - increased in the Maghrib. Such conclusions fit well with part of Ibn Khaldun's theory, which states that: science and scientific instruction *decreased* and eventually *disappeared or ceased* to be cultivated in the Maghrib and Spain simply because these countries were ruined.

The next chapter examines the fate of astronomy in Persia between the eleventh and sixteenth-centuries, to see how far it fits with the four theatrical claims made in Chapter Four.

6

THE FATE OF ISLAMIC ASTRONOMY IN PERSIA BETWEEN THE ELEVENTH AND SIXTEENTH CENTURIES

INTRODUCTION

The previous chapter has demonstrated that the fate of mathematics in the Maghreb fits well with part of Ibn Khaldun's theory, which states that: science and scientific instruction *decreased* and eventually *disappeared or ceased* to be cultivated in the Maghrib. This chapter examines the fate of Islamic astronomy in Persia between the eleventh and sixteenth centuries to see how far it fits with the four theoretical claims established in Chapter Four. However, three problems are posed immediately. First, due to the huge quantity in this field, it will not be possible to examine everything related to it. Second, almost always, those scientists who studied astronomy and made contributions to it also studied and contributed to mathematics. Third, because many astronomers travelled and worked in many different places, it is difficult to link them – at particular times - to certain places and not others. In order to overcome these problems this chapter will do the following. First, it shall only concentrate on the work of a few astronomers who belonged to Persia. Second, astronomical works will be highlighted and not mathematical ones. Third, an astronomer will be considered as belonging to the region in which he did most of his astronomical works.

This chapter is organised in the following manner. Section one gives a brief overview about important periods in the history of Islamic Astronomy. This is done in order to highlight the significance of choosing to examine the fate of astronomy in Persia and not elsewhere. Section two gives a brief background to one of the most important observatories in the history of Islamic astronomy: the Maragha observatory. Section three highlights some of the most important astronomical contributions of the Maragha observatory. Section four describes the impact of this Islamic astronomical tradition upon the work of Copernicus. The final section gives concluding remarks about the fate of Islamic astronomy in Persian between the eleventh and sixteenth-centuries.

1. Important Periods in the History of Islamic Astronomy

Before proceeding to examine the development of astronomy in Persia, it is necessary to give a brief – but important – overview of two important periods of Islamic astronomy. The history of Islamic astronomy can be broadly divided into two major periods, the eleventh century being the dividing road between the two.[1] From the ninth to the eleventh century, astronomical work was "almost exclusively in the area of geometrical models inherited from Ptolemy, reworked and criticised on the bases of new observations."[2]

Ptolemy was one of the most influential Greek astronomers and geographers of his time. He postulated the geocentric theory of the world in a form that prevailed

[1] Régis Morelon, "General Survey of Arabic Astronomy," in Roshdi Rashed (ed), *Encyclopaedia of The History of Arabic Science*, 1, (London: Routledge, 1996), p. 17.
[2] *Ibid.*

for 1400 years. Ptolemy's geocentric description of the universe was based on "two postulates of ancient astronomy: the earth is stable at the centre of the world, and all celestial motion must be explained by a combination of uniform circular movements."[3] It is a view of the world based on a fixed earth around which the sphere of the fixed stars rotates every day, carrying with it the spheres of the sun, moon, and planets. Ptolemy used geometric models to predict the positions of the sun, moon, and planets, using combinations of circular motion known as epicycles and eccentrics based on pervious work done by Hipparchus.[4] This view of the world was recorded in his famous work *Almagest*, which became available in Arabic under the caliph of Baghdad al-Ma'mun (813-33).[5] However, astronomers in Baghdad did not accept Ptolemy's work on face value. They re-examined the theoretical base of his results, in order to revise the mechanisms he had proposed and recalculate the parameters of the different movements.[6]

Criticism of Ptolemy pointed out that his mathematical models that describe the behaviour of physical spheres were: "fundamentally flawed in that they implied a contradiction between the physical properties of those spheres and the manner in which their motions were described mathematically."[7] From that perspective, the most outstanding problem that permeated the whole of Ptolemaic astronomy implied the uniform rotation of a sphere around an axis that did not pass through

[3] *Ibid,* p.4.
[4] *Ibid.*
[5] *Ibid.,* p.25.
[6] *Ibid.*
[7] A.I. Sabra, "Configuring the Universe: Aporetic, Problem Solving, and Kinematic Modeling as Themes of Arabic Astronomy," *Perspectives on Science*, 6, Fall 1998, i3.

its centre.[8] This very problem was later identified by astronomers working in the Islamic civilization as the equant problem and was also identified for the same purposes by Copernicus (d. 1543) in the introduction to his *Commentariolus*, which was written around 1510-1515.[9]

Efforts to resolve this problem began in earnest in the Islamic civilization sometime around the middle of the thirteenth century. Many astronomers attempted to devise non-Ptolemaic mathematical models that would still describe the motions of the celestial spheres in accordance with observations but would, at the same time, remain consistent with the physical properties of those spheres.[10] In these attempts at model construction, two astronomers in particular (whose works are discussed later), Mu'ayyad al-Din al-Urdi (d. 1266) and Nasir al-Din al-Tusi (d. 1274), devised two new mathematical theorems, unknown in the earlier Greek tradition, would serve this purpose.[11] These theorems are now known in the literature as the "Tusi Couple" and the "'Urdi Lemma." For both Tusi and 'Urdi, "the problem to be solved was exactly that posed by Ibn al-Haytham, and the solutions proposed by both (and later by Qutb al-Din al-Shirazi, a student of Tusi) betray the presuppositions and limitations that characterised the approach of the eleventh century mathematician."[12] This tradition continued with astronomers

[8] *Ibid.*
[9] *Ibid.*
[10] *Ibid.*
[11] *Ibid.*
[12] *Ibid.*

working in later centuries, particularly, Ibn al-Shatir (d. 1375) who worked in the central mosque of Damascus in the fourteenth century. [13]

In the eleventh century, Ibn al-Haytham (965-1039) criticised the work of Ptolemy in his work *al-Shukūk 'ala Batlamyūs* (Doubts concerning Ptolemy), in which he highlighted all the "still unresolved inconsistencies" in three of Ptolemy's works, but without proposing solutions.[14] Ibn al-Haytham stated, "The arrangement proposed for planetary motions in the Almagest were 'false' and the true arrangements were yet to be discovered."[15] Ptolemy's work was also criticised by an unknown astronomer in a book called *al-Istidrāk 'ala Batlamyūs*, which has not yet been located.[16] This trend of criticising Ptolemy's work became known as the astronomical school of Ibn al-Haytham, which lasted until other solutions were sought and found in the eastern part of the Muslim empire.[17]

Ibn al-Haytham's work led Muslims to search for solutions to Ptolemy's inconsistencies. In Andalusia (Muslim West) there were proposals to re-adopt Aristotelian principles.[18] The best representative of this school was al-Bitrūjī (end of twelfth century). These proposals, however, were philosophical solutions

[13] *Ibid.* Also see E.S. Kennedy, "An Islamic Response to Greek Astronomy: Kitab Tad dil Hay at al-Aflak of Sadr al-Sharia," *The Journal of the American Oriental Society*, 117, n2, April-June 1997, p.384 (2).

[14] Morelon, o*p. cit*.,.p.17

[15] A. H. Sabra, "The Andalusian revolt Against Ptolemaic Astronomy," in Everett Mendelsohn (ed), *Transformation and Tradition in the Science*s (New York: Cambridge University Press, 1984), p. 134.

[16] George Saliba, "Arabic Planetary Theories after the eleventh century AD," in Roshdi Rashed (ed), *Encyclopaedia of The History of Arabic Science*, *op.cit.,* 1, p.74.

[17] *Ibid.*

[18] This was to be done by "abandoning epicycles and eccentrics and returning to homocentric spheres, which would be much more consistent form a 'physical' astronomy point of view." Morelon, o*p.cit*., p.17

whose conclusions could not allow practical calculations to be made or to be verified by numerical observations.[19] This school was therefore unsuccessful in producing alternate results even though its philosophical processes "remain interesting."[20]

In the Muslim East, the response was different in the sense that it was scientific and not philosophical, which gave rise to what is called "the great period of Islamic astronomy."[21] This period witnessed the rise of research into the movement of heavenly bodies using non-Ptolemaic models.[22] This led to new contributions to astronomy, which eventually led to the Copernican heliocentric model of the universe – as shall be seen later on in this chapter. The essential part of that important research was done by a group of eminent scientists working in the Maragha observatory near Tabriz in north west Iran.[23]

2. THE MARAGHA OBSERVATORY: BRIEF BACKGROUND

Towards the end of the eleventh century (the supposed century of decline) a large and highly organised observatory was founded in Iran.[24] This observatory was founded by Malikshah (1072-92) and had amongst its eminent scientists Omar al-Khayyam. The plan was that this observatory was meant to operate for thirty

[19] Morelon, o*p.cit*., p.17
[20] *Ibid.*
[21] *Ibid.* p.18.
[22] *Ibid.*
[23] *Ibid.* p.13
[24] *Ibid*

years, but it only lasted for eighteen years – until the death of its founder.[25] It was the first official observatory that lasted for that long, and more importantly, it was in this tradition that the famous Maragha observatory was constructed in the second half of the thirteenth century, marking an important turning point in the history of astronomy.[26]

The Maragha observatory was known for the high quality instruments it possessed, a very important scientific library with about 400,000 books attached to it,[27] a foundry for the construction of the copper apparatus,[28] and the well organised work of "extremely high-calibre researches working in it."[29] Amongst these researches were: Nasir al-Din al-Tusi (1201-74), Mu'ayyid al-Din al-'Urdi (d.1266), Muhyi al-Din al-Maghribi, Fakhr al-Din al-Maraghi, Ali ibn 'Umar al-Qazwini, Najm al-Din al-Abhari, Qutub al-Din al-Shirazi, and the Chinese scholar Fao Mun-ji, all of whom extended the astronomy of Ptolemy.[30] The astronomical contributions of some of these scientists will be examined later in the chapter. It should be noted that the reform to the Ptolemaic astronomy started before the establishment of the Maragha observatory, but reached its heights in the fourteenth century. In fact, some of the astronomers at Maragha had already

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25 *Ibid*

26 *Ibid*. Also see A. Sayili, *The Observatory in Islam and its place in the general History of the Observatory* (Ankara: The Turkish Historical Society, 1960), pp. 188-223.

27 Ahmad Y Al-Hassan, "Factors behind the decline of Islamic science after the sixteenth century," in Sharifah Shifa Al-Attas (ed.), *Islam and the Challenge of Modernity: History and Contemporary Contexts* (Kuala Lumpur: International Institute of Islamic Thought and Civilisation, 1996).

28 Sayili, o*p. cit.,* p.14

29 *Ibid*., p.13.

30 *Ibid.,* p.14. Also, Charles Coulston Gillispie (ed), *Dictionary of Scientific Biography* (New York: Charles Scriber's Sons, 1976), XII, p.508-513.

started their reform work before joining the Maragha observatory, and it is perhaps because of this that they were invited to work at Maragha.[31]

Berggren[32] informs us that more recent research has shown that the reform movement of Ptolemaic astronomy began with Alhazen in the eleventh century. This reform movement was later developed at the Maragha observatory, and the first serious non-Ptolemaic models were proposed by al-'Urdi in the mid thirteenth century, and were developed later in that century by al-Tusi and al-Shirazi.[33] These non-Ptolemaic models were the source of continued research through the seventeenth century.[34] The reform of astronomy was made successful primarily due to the 'Tusi couple.' Saliba's book, *A History of Arabic Astronomy: Planetary Theories during the Golden Age of Islam*,[35] treats many aspects of this reform movement, in particular the Tusi couple and 'Urdi's Lemma, both of which played important roles in the whole development, as well as the discussion of the mathematical equivalence of earlier models developed by the Maragha school to those of Copernicus.[36]

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[31] This is true in the case of Nasir al-Din al-Tusi and al-'Urdi. See George Saliba, *Kitab al-Hya'ah – The astronomical work of Mu'ayyad al-din al-'Urdi* (Centre for Arab Unity Studies, 1990), pp.31f; and F J. Ragep, *Nasir al-Din al-Tusi Memoir on Astronomy*, 2 vol. (New York: Springer-Verlag, 1993), pp. 65f.
[32] J. Lennart Berggren, "Mathematics and Her Sisters in Medieval Islam: A selective review of work done from 1985 to 1995," *Historica Mathematica,* 24, 1997, p.23-24.
[33] *Ibid.*, p.24.
[34] *Ibid*
[35] George Saliba, *A History of Arabic Astronomy: Planetary Theories during the Golden Age of Islam* (New York: New York University Press, 1994).
[36] Berggren, o*p. cit*., p.24.

In the Maragha observatory new set of astronomical tables – called Ilkhanian tables - were formulated.[37] Also, scientists working at Maragha were able to produce "better geometrical models than those of Ptolemy to account for the movements of celestial bodies."[38] More importantly, this observatory initiated the establishment of other significant observatories in Samarkand, Istanbul and India. The most famous of these is the one built in Samarkand by Ulugh Beg, who was an eminent scientist. This observatory lasted until nearly 1500.[39]

Ironically, Hulagu Khan (who sacked Baghdad in 1256) financed the Maragha observatory with large sums of revenue for its maintenance.[40] The activity of al-Maragha observatory lasted until the early fourteenth century (1316) the date of the death of its last known director, Asīl al-Din, who directed it for fourteen years.[41]

3. THE MARAGHA OBSERVATORY: SIGNIFICANT ASTRONOMICAL CONTRIBUTIONS

It was said above that Malikshah founded the most important observatory during the eleventh century. Amongst its greatest scientists was Omar al-Khayyam, who is known for his *Rubaiyyat* more than anything else.[42] Generally, however, the eleventh century did not witness new contributions in astronomy other than the

[37] Morelon, *op.cit*., p.13.
[38] *Ibid*
[39] *Ibid*. p.14
[40] *Ibid*. p.13
[41] *Ibid*. p.14
[42] Abdul Latif Samian, "The growth and Decline of Islamic astronomy," *Islamiyyat*, 14, 1993, p.19.

"continuous and parallel developments observed in the preceding eras,"[43] with the exception of new technological contributions in the form of instrument making.[44] During the twelfth century "several proposals to improve the dominant Ptolemaic astronomy with several mathematical models,"[45] were suggested, but no notable contributions were made.[46] Original and influential contributions flourished later by astronomers of the Maragha Observatory. The following will show that astronomers of the Maragha observatory not only produced original work in astronomy, but also "left their imprint on later astronomical research, mainly in the Latin West, and may perhaps have laid the foundation for Copernican astronomy itself."[47]

Mu'ayyid al-Din al-'Urdi (d.1266)

While al-'Urdi made original contribution to a number of scientific disciplines, emphasis here will only be on his astronomical contributions – and the same is true regarding other astronomers discussed below. Al-'Urdi was the first astronomer associated with the Maragha School to construct planetary models before 1259 AD.[48] Al-'Urdi designed some of the instruments at the Maragha Observatory, but more importantly he was also the first astronomer to offer alternative models to those of Ptolemy,[49] which were developed later in the

[43] *Ibid.*
[44] *Ibid.*
[45] *Ibid.*
[46] *Ibid.*
[47] George Saliba, "Arabic planetary theories after the eleventh century AD," in Roshdi Rashed (ed.) *Encyclopaedia of the History of Arabic Science*, *op.cit*., 3, p.59.
[48] Samian, o*p.cit*., p.21.
[49] *Ibid.*

thirteenth century by Nasir al-Din al-Tusi and his student Qutb al-Shirazi,[50] and perfected by Ibn al-Shatir (Damascus) in the fourteenth century – whose planetary models "and those of Copernicus are virtually identical, with only minor differences in some parameters."[51]

Al-'Urdi was known as an expert maker of astronomical instruments who was brought from Syria to supervise the construction of the Maragha.[52] His Book *Hay'a*, written before leaving Syria, demonstrates his rejection of views and procedures done by earlier competent Islamic astronomers.[53] Furthermore, al-'Urdi's book clearly shows that he was not completely satisfied with "the ancient observations believed to be true, such as those of Hipparchus and Ptolemy,"[54] and "his reluctance to pass judgment on them without having been able to test them."[55]

In the same book al-'Urdi lauds the study of astronomy as a universal pursuit that does not vary with place or time "or religion."[56] Mixing themes of Hellenic philosophy with others inspired by the Islamic revelation made al-'Urdi's astronomical arguments favour the promotion and perfection of Ptolemaic astronomy.[57] Al-'Urdi only lamented that he could not carry his own observations but accepted the earlier observations of Ptolemy and only objected to Ptolemy's

[50] Berggren, 1997, o*p. cit*., p.24.
[51] Toby Huff, *The rise of early modern science* (Cambridge: Cambridge University Press, 1993), p. 59.
[52] A. I. Sabra, 1998, o*p. cit.*
[53] *Ibid*
[54] *Ibid*
[55] *Ibid*
[56] *Ibid*
[57] *Ibid*

hypothesis of mathematical models.

Ultimately, for al-'Urdi the problem to be solved was exactly that posed by Ibn al-Haytham, and the solutions proposed by him and al-Tusi (and later by Qutb al-Din al-Shirazi, a student of Tusi) betray the presuppositions and limitations that characterised the approach of the eleventh century mathematician.[58] Al-'Urdi remarked that:

> Ptolemy, in his solar model opted for a single eccentric orb in preference to the combination of a concentric deferent and an epicycle (both moving with simple/uniform motions) because it was "simpler" to assume a single motion rather than two. [59]

Al-'Urdi then declared that he seeks:

> The simplest constructions possible by means of which the motions of the planets can be accomplished in a uniform circular manner, in accordance with what resembles and is appropriate for the nature of the heaven.[60]

But such an interpretation had to be satisfied by a dominant physical doctrine, and the observational evidence reported and argued in mathematical terms in *Almagest*.[61] These conditions existed for centuries, and "evidence of their

[58] *Ibid.*
[59] *Ibid.*
[60] *Ibid.*
[61] *Ibid.*

unresolved interaction with one another had been embarrassingly visible in Ptolemy's work itself."[62] These conditions were not invented by Muslim astronomers but were given to them,[63] and so "they needed to be reconciled, at least in the eyes of those who accepted them as equally indispensable,"[64] such as Ibn al-Haytham, al-'Urdi, al-Tusi, and, a century later, Ibn al-Shatir.

Al-'Urdi sought to achieve such a reconciliation in the construction of his new planetary models.[65] Thus, he:

> Utilised the concept to represent the mathematical character of the proposed devices as means of replacing a Ptolemaic variable-length vector rotating at constant velocity (the Ptolemaic equant vector) by linkages of constant-length vectors each rotating with a constant velocity, thereby disposing of the "impossible" constant-length deferent radius carrying the epicycle centre around at variable speed.[66]

Al-Urdi's arguments against Ptolemy led to him to establish a new model of his own ('Urdi's Lemma), with which he was satisfied, consequently urging "the reader to accept it and to reject that of Ptolemy, since the latter had been shown to have been riddled with contradictions.[67] Later, Copernicus echoed al-'Urdi's

[62] *Ibid.*
[63] *Ibid.*
[64] *Ibid.*
[65] *Ibid.*
[66] *Ibid.*
[67] Saliba, 1996, o*p. cit*., p.92-93.

original contribution in *De Revolutionibus*.[68] But to understand the possible relationship between the Copernican model and that of al-‘Urdi it is necessary to investigate the contributions of al–Tusi, al-Shirazi and Ibn al-Shatir. Since the emphasis of this chapter is on Persia, Ibn al-Shatir (who belongs to Damascus, Syria) will be referred to here, but examined in more details in the next chapter.

NASIR AL-DIN AL-TUSI (1201-1274)

Known as Nasir al-Din al-Tusi, his proper name was Muhammad ibn Muhammad ibn al-Hasan al-Tusi.[69] He is one of the most influential figures in Islamic intellectual history.[70] He was a distinguished scholar in astronomy, mathematics, mineralogy, logic, philosophy, ethics and theology.

Al-Tusi was the head of the Maragha observatory, and is one of the most prolific Islamic polymaths, with 150 known treatises and letters to his credit.[71] He became famous for his treatise *al-Tadhkira* in which he discusses the problems with Ptolemy’s lunar model, and tries to find solutions to them.[72] Al-Tusi’s major contributions to astronomy consisted of his criticism of Ptolemaic astronomy, and the proposal of a new theory of planetary motion.[73]

[68] *Ibid.*
[69] Gillispie, *op. cit*., p.508.
[70] *Ibid.*
[71] Owen Gingerich**,** “Islamic astronomy,” *Scientific American*, 254, April 1986, p.74 (10).
[72] Saliba, *op. cit*. p.93.
[73] Gillispie, *op. cit*., p.511.

Without going into technical details,[74] according to al-Tusi the problem in the Ptolemaic lunar model was its inability "to allow the centre of the epicycle to approach the centre of the universe and to draw away from it without having to incorporate the crank-like mechanism of Ptolemy."[75] It was in that context that al-Tusi "proposed a new mechanism in his book *Tahrir al-Majisti* ('A Redaction of the Almagest, composed in 1247)." In *al-Tadhkira*, al-Tusi:

> Devised a new model of lunar motion, essentially different from Ptolemy's. Abolishing the eccentric and the centre of prosneusis, he founded it exclusively on the principle of eight uniformly rotating spheres and thereby succeeded in representing the irregularities of lunar motion with the same exactness as the *Almagest*. His claim that the maximum difference in longitude between the two theories amounts to 10' [10 minutes] proves perfectly true. In his model Nasir, for the first time in the history of astronomy, employed a theorem invented by him, which, 250 years later, occurred again in Copernicus, *De Revolutionibus*, III 4.[76]

The theorem referred to above concerns what Kennedy[77] called the "Tusi-couple." The aim of al-Tusi with this result was to remove all parts of Ptolemy's system that were not based on the principle of uniform circular motion. Once that was achieved using his "Tusi-couple":

[74] For an explanation of such details see Saliba, 1996, *op. cit*. pp.58-127.
[75] Saliba, 1996, *op. cit*., p.93.
[76] W. Hartner, "Nasir al-Din al-Tusi 's lunar theory," *Physis - Riv. Internaz. Storia Sci.* 11, 1969, pp. 287-304.
[77] E. S. Kennedy, "Late Medieval Planetary Theory," *Isis*, 57, 1966, 1vii, pp.367-78.

> There was no longer any need for the eccentric deferent of Ptolemy, nor for his crank-like mechanism, both of which were originally required to bring the lunar epicycle closer to the earth at quadrature and further away at conjunction and opposition.[78]

Though al-Tusi made numerous other contributions to astronomy, however, his most important contribution was the so-called 'Tusi couple.' With the help of this theory (and 'Urdi's Lemma, examined above), and with the "technique of dividing the eccentricities of the Ptolemaic models, it was possible to transfer segments of these models from the central parts to the peripheries and back."[79] In addition, the Tusi couple allowed "the production of linear motions as a combination of circular motions, and thus allowed someone like Ibn al-Shatir, and after him Copernicus, to create the effect of enlarging the size of the epicycle radius and of shrinking it by using uniform circular motion only or combination thereof."[80]

Al-Tusi's work was carried on by other astronomers of the Maragha School, which "succeeded in producing the non-Ptolemaic planetary models that were duplicated in the work of Copernicus."[81] Al-Tusi's original contribution in astronomy is considered "the most important departure from Ptolemaic astronomy before modern times."[82] With the exception of Copernicus' heliocentric thesis, "the novelty of Copernicus' astronomy is already found in the works of al-Tusi

[78] Sabra, *op. cit*., p.94.
[79] Saliba, 1996, *op. cit*. p. 125.
[80] *Ibid*.
[81] Huff, *op. cit.,* p.57.
[82] Gillespie, *op. cit*., p.511.

and his followers, which probably reached Copernicus through Byzantine intermediaries."[83]

QUTB AL-DIN AL-SHIRAZI (1236-1311)

Al-Shirazi joined the Maragha Observatory around 1262, and became Tusi's foremost student. He remained at Maragha a long period before he moved to Khurasan, Baghdad, Konya, Sivas, Molatya, Tabriz and other areas.[84] Al-Shirazi wrote on optics, medicine, philosophy and astronomy. Here we shall consider his contributions in astronomy during his stay at the Maragha observatory.

Al-Shirazi emphasised the relation between the movement of the sun and the planets in the way that is found later in the writings of Regiomontanus, and which prepared the way for Copernicus.[85] In two of his most famous books, *Nihaya and al-Tuhfat al-Shahiyya*, al-Shirazi sought to reach a completely satisfactory planetary model, and the solutions he arrived at were amongst his most important achievements.[86] The details of this model are beyond the scope of this chapter, but can be found in the work of scholars like E. S. Kennedy.[87]

In his book *Nihaya*, Shirazi wanted to find solutions to the objections raised against Ptolemaic models. However, he did not arrive at any new model, though

[83] *Ibid.*
[84] *Ibid,* vol. XI, p.248.
[85] Gillespie, *op. cit*., vol. XI, p.250.
[86] *Ibid.*
[87] See for example E. S Kennedy, "Late Medieval Planetary Theory," *Isis*, 57, 3, 1966, p.376 and 373.

he concluded that Tusi's models did not answer objections to the lunar model, and 'Urdi's model was preferred.[88] In his *Tuhfa*, Shirazi proposed a model of his own. Al-Shirazi's model represents the height of the technique developed at Maragha to solve the problems of planetary motion. He also applied these techniques to the solution of the problem of the moon, trying to remove some of the obvious flaws in the Ptolemaic model.[89] It was shown above that al-Tusi found the equant of Ptolemy particularly unsatisfactory. In his *Tadhkira* he replaced it by adding two more small epicycles (Tusi couple) to the model of each planet's orbit. Through this device al-Tusi was able to achieve his goal of generating the non-uniform motions of the planets by combinations of uniformly rotating circles.[90] The centres of the deferents, however, were still displaced from the earth.

Qutb al-Din al-Shirazi offered an alternative arrangement but this system too retained the philosophically objectionable eccentricity.[91] Ibn al-Shatir of Damascus was more successful, for he produced a model that "was greatly superior to that of Ptolemy," [92] and "mathematically equivalent to those of Copernicus elaborated some 150 years after the time of Ibn al-Shatir."[93] Ibn al-Shatir played the most significant role in the development of theoretical planetary models and overcome the problems associated with Ptolemaic planetary models.[94] However, he arrived at such a model building on the work of astronomers like al-

[88] Saliba, 1996, *op. cit*., p.97-98.
[89] Gillespie, *op. cit*, vol. XI, p.251.
[90] Gingerich, *op. cit*
[91] *Ibid.*
[92] Gillespie, vol. XI, *op. cit*., p.251.
[93] David A. King, "The astronomy of the Mamluks," *Isis*, 74, 1983, p.539.
[94] *Ibid.,* p.538.

Tusi, al-‘Urdi and al-Shirazi.[95]

4. Impact on the Work of Copernicus

It was noted above that a completely concentric rearrangement of the planetary mechanisms was achieved by Ibn al-Shatir, who worked in Damascus in about 1350. By using a scheme related to that of al-Tusi, Ibn al-Shatir succeeded in eliminating not only the equant but also certain other objectionable circles from Ptolemy’s constructions. He thereby cleared the way for a perfectly nested and mechanically acceptable set of celestial spheres. Yet Ibn al-Shatir’s solution, along with the work of the Maragha astronomers, remained generally unknown in medieval Europe.[96]

E. S. Kennedy and his students at the American University of Beirut rediscovered Ibn al-Shatir’s forgotten model in the late 1950’s. From this it was recognized that “Ibn al-Shatir and the Maragha inventions were the same type of mechanism used by Copernicus a few centuries later to eliminate the equant and to generate the intricate changes in the position of the earth’s orbit.”[97] Copernicus, of course, adopted a heliocentric arrangement, “but the problem of accounting for the slow but regular changes in a planet’s orbital speed remained exactly the same.”[98] Since Copernicus agreed with the philosophical objections to the equant - like some of

[95] *Ibid.*
[96] Gingerich, *op. cit.*
[97] *Ibid.*
[98] *Ibid.*

his Islamic predecessors - he too sought to replace Ptolemy's device.[99] In a preliminary work - the *Commentariolus*, he employed an arrangement equivalent to that of Ibn al-Shatir. Later, in *De revolutionibus*, "he reverted to the use of eccentric orbits, adopting a model that was the sun-centred equivalent of the one developed at Maragha."[100]

According to Kennedy,[101] the resemblance between the work of Copernicus and the Islamic astronomers who preceded him are outstanding:

1) Copernicus, Ibn al-Shatir, and the astronomers of the Maragha School accepted without reservation the dictum that any celestial model must be a linkage of constant-length vectors rotating at constant angular velocity
2) Copernicus, Ibn al-Shatir, and the Maragha School obtained the effect of the equant by introducing two additional vectors into the planetary linkage, both of length half the eccentricity.
3) Copernicus' lunar model, which is greatly superior to the Ptolemaic one, is that of Ibn al-Shatir
4) Copernicus' Mercury model (in *De revolutionibus*) is that of Ibn al-Shatir with slight differences in vector lengths.
5) Copernicus uses a Tusi couple in the Mercury model (as does Ibn al-Shatir).

More recently, Saliba claims that early in his works, Copernicus - like the Muslim

[99] *Ibid.*
[100] *Ibid.*
[101] E. S. Kennedy, "Late Medieval Planetary Theory," *Isis*, 57, 1966, pp.366-377.

astronomers - was troubled by the mathematical inconsistencies of Ptolemy, "but it was the problem of the equant that disturbed him more than the geocentric cosmology."[102] Furthermore, since Copernicus still viewed celestial motions as circular rather than elliptical and so still required the equant to describe elliptical motions, a heliocentric universe would not have solved the problem of the equant in any case.[103] Thus, according to Saliba, a close inspection of Copernicus's work shows that the only two theorems Copernicus used that weren't already in the classical Greek sources were the 'Urdi Lemma and the Tusi Couple.[104] Copernicus was using the 'Urdi Lemma and the Tusi Couple in the sixteenth century to solve precisely the same problems that faced the Islamic astronomers in the thirteenth century.[105]

The question that is being asked by scholars is how could someone like Copernicus become familiar with the ideas of 'Urdi, al-Tusi and Ibn al-Shatir, when apparently he could not read Arabic, and as far as known the Arabic works had not been translated into Latin?[106] Recent research gives some interesting clues. For example, the Austrian-American historian Otto Neugebauer drew attention to "a Byzantine Greek manuscript, translated from Arabic, which contained some of the results obtained by the Islamic astronomers."[107] Since "Copernicus did read Greek," and he may have had the opportunity to see

[102] Saliba, "Greek astronomy and the medieval Arabic tradition: the medieval Islamic astronomers were not merely translators. They may also have played a key role in the Copernican revolution," *American Scientist*, 90, 4, July-August 2002, p.360(8).
[103] *Ibid.*
[104] *Ibid.*
[105] *Ibid.*
[106] *Ibid.*
[107] *Ibid.*

Byzantine Greek manuscript “early in the sixteenth century in the course of his studies in Italy (where the manuscript now resides).”[108]

More recently, Saliba has uncovered in different European libraries several Arabic manuscripts on planetary astronomy, including a copy of Tusi’s critique of Ptolemy.[109] The manuscripts “appear to have been owned by Copernicus’s contemporaries, who could read Arabic very well as evidenced by many Latin notes they left on the margins.”[110] But the question that is posed by Saliba is this: “Did those contemporaries, or their colleagues, ever communicate this knowledge to Copernicus?”[111] Others, like Stacewicz-Sapuntzakis and Andrea Pontecorvo-Martonffy, ask: is it “possible that Copernicus was not aware of the precise origins of these theorems, or that to acknowledge them might have proved difficult in the charged anti-Islamic atmosphere era of the early 16th century?”[112] But Saliba claims that, “we know that Copernicus had no qualms about mentioning other Islamic astronomers, such as al-Battani and Arzachel, among others, when he knew his sources. But when he did not know, as seems to be the case here, he simply remained silent.”[113]

Other recent studies by Saliba show that the astronomical works of al-Tusi were continued during the sixteenth century. Saliba studies on a commentary on the *Tadhkira* of Tusi himself, which was written by Shams al-Din al-Khafri (d. after

[108] *Ibid.*
[109] *Ibid.*
[110] *Ibid.*
[111] *Ibid.*
[112] Cited in: “In defence of Copernicus. (Letters to the Editors),” *American Scientist*, 90, 6, Nov-Dec 2002, p.492 (1).
[113] *Ibid.*

1525), shows that al-Khafri has gone far beyond all previous commentators in that he took it upon himself not only to explain the work of Tusi, but to complete that work and add to it all the parts left unfinished by Tusi. As a result, al-Khafri's commentary contains at least five mathematical models of his own creation in addition to the ones he credited to others.[114]

SUMMARY AND CONCLUSION

The aim of this chapter was to examine the fate of Islamic astronomy in Persia to see how far it fits with any of the four theoretical claims established in Chapter Four. This chapter demonstrated that Islamic astronomy in Persia flourished after the eleventh century. The period between the eleventh and sixteenth centuries was marked with intense astronomical activity. In the Maragha observatory in Persia, original contributions in astronomy (notwithstanding contributions in other scientific fields like mathematics) were made. The originality and importance of these contributions can be estimated by their impact upon later European astronomical research, which may perhaps have laid the foundation for Copernican astronomy itself.

This chapter also showed that in some of the most recent research in theoretical astronomy, historians of Islamic astronomy such as Saliba[115] have documented the highly original contributions of Mu'ayyad al-Din al-'Urdi (d.1266), Nasir al-Din

[114] Saliba, "Writing the history of Arabic astronomy: problems and differing perspectives," *The Journal of the American Oriental Society*, 116, 4, Oct-Dec 1996, p.709(10).
[115] Saliba, *Kitab al-Hya'ah; the Astronomical Work of Mu'ayyad al-Din al-'Urdi* (Center for Arab Unity Studies, 1990); Saliba, *A History of Arabic Astronomy. Planetary Theories during the Golden Age of Islam* (New York University Press, 1994).

al-Tusi (d.1274), and Qutb al-Din al-Shirazi (d.1311), between the thirteenth and sixteenth century. Such research shows that Ibn al-Shatir's highly sophisticated alternatives to the Ptolemaic models for planetary motion were simply one development in a tradition of reform of Ptolemaic astronomy that began with Alhazen in the eleventh century.[116] The first serious models in this reform movement, which were proposed by al-Urdi in the mid-thirteenth century, were developed later in the century by Nasir al-Din al-Tusi and his student Qutb al-Din al-Shirazi. These non-Ptolemaic models continued to be explored through the seventeenth century.[117]

More recently, historians of Islamic science and astronomy as Goldstein, Hartner, King, Sabra, Saliba, and Kennedy, have painted a "portrait that almost fully assimilates the scientific activity in Arab astronomy of the twelfth, thirteenth, and fourteenth centuries with the activities of such modern scientists as Copernicus, Galileo, Tycho Brahe, and Kepler."[118] Furthermore, studies by Neugebauer and Swerdlow establish that Islamic astronomy "must have had an impact on Copernicus himself, and only future research will reveal the exact nature of the channels of transmission from the East to the West that were responsible for this impact."[119]

This case study, like the one before it, clearly show that the idea that Islamic science "declined," "decayed," "froze," or suffered any other uniform single

[116] J. Lennart Berggren, "Mathematics and Her Sisters in Medieval Islam: A selective Review of Work Done from 1985-1995," *Historia Mathematica* 24, 1997, pp.407-440.
[117] *Ibid*.
[118] Huff, *op. cit*., p.57.
[119] Saliba, 2002, *op. cit*., p.125-126.

faceted fate is clearly erroneous. This case study further verifies that Ibn Khaldun's theory is essentially closer to reality, but is incomprehensive, since it says nothing about astronomy in Persia.

The next chapter examines the fate of astronomy in Egypt and Syria between the eleventh and sixteenth-centuries to see how far it fits with the four theoretical claims made in Chapter Four.

7

THE FATE OF ISLAMIC ASTRONOMY IN EGYPT AND SYRIA BETWEEN THE ELEVENTH AND SIXTEENTH CENTURIES

INTRODUCTION

Chapter Five has demonstrated that the fate of mathematics in the Maghrib fits best with part of Ibn Khaldun's theory, which, if it may be recalled, stipulate that: science and scientific instruction *decreased* and eventually *disappeared or ceased* to be cultivated in the Maghrib and Spain simply because these countries were ruined. Chapter Six has also demonstrated that the fate of astronomy in Persia fits best with the view that some branches of Islamic science flourished beyond the period of so-called decline, and that Ibn Khaldun's theory is essentially closer to reality, but is incomprehensive, since it says nothing about astronomy in Persia. This chapter will examine the fate of astronomy in Syria and Egypt between the eleventh and sixteenth centuries to see how far it fits with the four theoretical claims described in Chapter Four.

Syria and Egypt are examined together for the simple reason that the Ayyubids and Mamluks dynasties ruled them both, as will be shown next. Much of this chapter draws extensively on the work of Professor of the History of Science David A. King, who is a specialist on medieval Islamic science, Arabic scientific manuscripts and medieval Islamic and European scientific instruments. King has researched extensively in the area of astronomy in medieval Islam, and has done specific work on astronomy of the Mamluks.[1]

This chapter is organised in the following manner. Section one gives brief background information about the Mamluk and Ayyubid dynasties. Section two describes the Islamic tradition of astronomy under the Mamluks, with emphasis on the work of Ibn al-Shatir. Section three describes various other astronomical achievements under the Mamluks. The last section offers concluding remarks about the fate of astronomy in Egypt and Syria during the period under question, and how far that fits with the theoretical claims suggested in Chapter Four.

1. The Ayyubids And Mamluks In Syria and Egypt: Brief Overview

The Ayyubids dynasty came to power under the leadership of Salah al-Din (known as Saladin) in 1164.[2] After repulsing a Crusader army that had reached the gates of Fatimid Cairo, Salah al-Din declared the Fatimid caliphate to be at its end, and established the Ayyubid sultanate (1171). After the death of Nūr al-Din Mahmūd ibn Zangi (the ruler of Syria) in 1174, Salah al-Din became ruler of both Egypt and Syria.[3] The Ayyubid sultanate depended on Mamluk soldiers for its military organization, and it is these soldiers that eventually brought the end of the

[1] Some of Kings publications include: *A Catalogue of the Scientific Manuscripts in the Egyptian National Library* [in Arabic], 2 vols., (Cairo: General Egyptian Book Organization, 1981-86). *A Survey of the Scientific Manuscripts in the Egyptian National Library*, (Publications of the American Research Center in Egypt), Catalogs, vol. 5. (Winona Lake, Indiana: Eisenbrauns, 1986). *Mathematical Astronomy in Medieval Yemen - A Bio-Bibliographical Survey*, (Publications of the American Research Center in Egypt, Catalogs, vol. 4). (Malibu, California: Undena Publications, 1983). *Islamic Mathematical Astronomy*. (London: Variorum, 1986), 2nd rev. edn., (Aldershot: Variorum, 1993). *Islamic Astronomical Instruments*. (London: Variorum, 1987, repr. Aldershot: Variorum, 1995).
[2] Emilie Savage-Smith, 'Medicine,' in Roshdi Rashed (ed), *Encyclopaedia of the History of Arabic Science*, 3, (London: Routledge, 1996), p.930.
[3] *Ibid.*

Ayyubid sultanate in 1250,[4] and the end of the Mongol invasions. The Mamluks ruled Egypt and Syria for two and a half centuries.[5] Thus, regular and frequent contacts were made between both areas and subsequently between their scientists.[6]

The Mongols conquered Inner Asia, China, Russia, and much of the Middle East, creating the largest Empire of all time. But they failed to take Syria and Egypt, despite efforts continuing for over half a century. They could not overcome the resistance of the Mamluks (slave soldiers who dominated the government and army of Egypt.)[7] Since taking power in Cairo in the thirteenth century, the Mamluks had been the mightiest force in the Middle East. It was they who chased the crusaders out of Palestine, they whose superb cavalry fought off Genghis Khan and his Mongol army in 1260.[8]

Within a short period of time, the Mamluks created the greatest Islamic Empire of the later middle Ages, which included control of the holy cities of Mecca and Medina. The Mamluk capital, Cairo, became the economic, cultural, and artistic centre of the Arab Islamic world.[9] Medicine, astronomy, architecture, metalwork, book production and binding, glassware and ceramics prospered under the Mamluks.[10] Furthermore, both Damascus and Cairo made improvements on

[4] *The Economist (US),* 'The Turkish Empire: Goodbye to the Mamluks,' Dec 25, 1999, 353, 8151, p.68.
[5] *Ibid.*
[6] *Ibid*, p.93.
[7] *John Masson Smith Jr.*, "Mongols and Mamluks: The Mamluk-Ilkhanid War, 1260-1281." (book reviews) *The Journal of the American Oriental Society*, 118, 1, Jan-March 1998, p.54(9).
[8] *The Economist (US)*, 'The Turkish Empire…' *op.cit*., p.68.
[9] *Ibid,* p.93.
[10] *Ibid.*

hospitals, public and religious buildings, canals, bridges and the postal service, resulting to better communication between both cities.[11]

2. Astronomy Under The Mamluks

According to King, Baghdad and Iran were the centres of mathematical astronomy in the Islamic Empire during the eleventh century.[12] Around the same time, Egyptian and Syrian astronomers began to rival their contemporaries in Baghdad and Iran.[13] Consequently, Rakka (Syria) in the early tenth century, and Cairo in the late tenth century, became among the leading astronomical centres in the world.[14] A number of famous astronomers hailed from these centres. From Rakka came the renowned astronomer al-Battani, whose work was influential in Europe in later centuries.[15] And from Fustat (Egypt) came celebrated astronomers as Ibn Yunus, and Ibn al-Haytham – who wrote extensively on the problems of Ptolemy's planetary models.[16] Thus, astronomical activities in Syria and Egypt were present before the Mamluks and, according to recent research, continued through the Mamluks and Ottoman periods.[17]

The revival of astronomy under the Mamluk was a direct consequence of the death of a group of eminent Syrian and Egyptian astronomers.[18] This revival made Syria and Egypt important centres for astronomical activity. Until the early

[11] *Ibid.*
[12] David A. King, "The Astronomy of the Mamluks: A Brief Overview," in Oleg Grabar (ed.), *Muqanas II: An Annual on Islamic Art and Architecture* (New haven: Yale University, 1984), p.73.
[13] *Ibid.*
[14] *Ibid.*
[15] *Ibid.*
[16] David A. King, "The Astronomy of the Mamluks," *Isis*, 74, 1983, p.532.
[17] King "The Astronomy of the Mamluks: A Brief Overview," o*p.cit*., p.73.
[18] King, "The Astronomy of the Mamluks," o*p.cit*., p.533.

fourteenth century, Cairo was the more important of the two. It is now known that Syrian astronomers came to Cairo to study astronomy.[19] However, in the mid-fourteenth century Damascus became the leading centre of astronomical activity, "not only in the Mamluk Empire, but in the Islamic world as a whole, as the school of astronomers associated with the Umayyad Mosque far surpassed those working in Cairo or anywhere else."[20] However, when Timur destroyed Damascus in 1401, Cairo became the more important centre again.[21]

Recent research in the astronomy of the Mamluks also shows that major Mamluk astronomers were *muaqqits* (time-keepers).[22] These were astronomers employed by mosques and *madrasas* (schools) for astronomical timekeeping, and the regulation of the times of prayer.[23] Recent studies of primary sources in Islamic astronomy demonstrate that *muaqqits* contributed much to the development of science.[24] Amongst the most famous of the Syrian and Egyptian astronomers are: Ibn al-Shatir, al-Khalili, Ibn al-Sarraj and al-Mizzi,[25] whose work has only been studies in the last few years, many of which are unpublished.[26] In what follows, the astronomical work of Ibn-al-Shatir will be examined in some detail.

[19] King, "The Astronomy of the Mamluks: A Brief Overview," *op.cit.*, p.73.
[20] *Ibid.*
[21] *Ibid.*
[22] *Ibid.*
[23] King, "The Astronomy of the Mamluks," o*p.cit.*, p.534. Also see David A. King, "On the Role of the *Muaqqit* in medieval Islamic Society," *Proceedings of the Second International Symposium on the History of Arabic Science* (Aleppo, 1979).
[24] King "The Astronomy of the Mamluks: A Brief Overview," *op.cit.*, p.74.
[25] King, "The Astronomy of the Mamluks," o*p.cit.*, p.536.
[26] *Ibid*, p.552.

Theoretical Astronomy of Ibn al-Shatir (1304-1375)

The important work of Ibn al-Shatir was briefly highlighted in Chapter Six. However, it is more appropriate to examine his astronomical contributions in this chapter, simply because Ibn al-Shatir belonged to Damascus – the region of our interest here. The following, then, is a somewhat detailed account of Ibn al-Shatir's important astronomical work.

The previous chapter explained that astronomers in the Islamic world were dissatisfied with Ptolemy's planetary theory and thus occupied themselves with refining the intricacies of this theory. It was also pointed out that the mathematical models that were used by Ptolemy were fundamentally flawed. The most outstanding problem that permeated the whole of Ptolemaic astronomy implied the uniform rotation of a sphere around an axis that did not pass through its centre. Ptolemy's planetary models had the sun, the moon and the planets moving around the earth.[27] However, a simple circular orbit "could not account for the fact that a planet periodically seems to reverse its direction of motion across the sky."[28] Ptolemy, therefore, had each planet moving on an epicycle,[29] which - together with other geometric devices invented by Ptolemy – "gave a fairly good first approximation to the apparent motion of the planets."[30] This came to be known amongst Muslim astronomers as the equant problem. This "notion of

[27] Owen Gingerich, "Islamic astronomy," *Scientific American*, 254, April 1986, p.79
[28] *Ibid.*
[29] *Ibid.*
[30] *Ibid.*

the equant was the 'last straw' for some Islamic astronomers"[31] for their criticism of Ptolemy, "simply because it was physically nonsensical."[32]

This led to two types of criticism of the Ptolemaic system, which came in the twelfth and thirteenth centuries in Spain and Persia. Many astronomers attempted to devise non-Ptolemaic mathematical models that would still describe the motions of the celestial spheres in accordance with observations but would at the same time remain consistent with the physical properties of those spheres. Chapter Six showed that in their attempts of model construction two astronomers, Mu'ayyad al-Din al-Urdi (d. 1266) and Nasir al-Din al-Tusi (d. 1274), devised two new mathematical theorems, that were not known in the earlier Greek tradition, that would solve the equant problem.

Al-'Urdi managed to find a solution for the planetary equant,[33] using what is now called the Lemma theorem to "reproduce the apparent motions of the planets with a deferent that moved uniformly in place around an axis that passed through its centre."[34] This same theorem was used centuries later by Copernicus to account for planetary motions in his heliocentric cosmology.[35] On the other hand, al-Tusi replaced the equant by adding two more small epicycles to the model of each planet's orbit,[36] which came to be known as the Tusi Couple. With this device al-Tusi was "able to achieve his goal of generating the non-uniform motions of the

[31] George Saliba, "Greek astronomy and the medieval Arabic tradition: the medieval Islamic astronomers were not merely translators. They may also have played a key role in the Copernican revolution," *American Scientist*, 90, 4, July-August 2002, p.365.
[32] *Ibid.*
[33] *Ibid.*, p.366.
[34] *Ibid*.
[35] *Ibid*.
[36] Gingerich, *op.cit.,* p.79

planets by combinations of uniformly rotating circles."[37] But the centres of the deferents were still displaced from the earth.[38] Mu'ayyad al-Din al-'Urdi and Qutb al-Din al-Shirazi "offered an alternative arrangement, but this system too retained the philosophically objectionable eccentricity."[39]

Ibn al-Shatir (d. 1375) of Damascus used the Tusi Couple and Urdi Lemma to produce a model that "was greatly superior to that of Ptolemy,"[40] and "mathematically equivalent to those of Copernicus elaborated some 150 years after the time of Ibn al-Shatir."[41] Thus, Ibn al-Shatir played the most significant role in the development of theoretical planetary models to account for the motions of the sun, moon, and planets and overcome the problems associated with Ptolemaic planetary models.[42] In doing so, he "succeeded in eliminating not only the equant but also certain other objectionable circles from Ptolemy's constructions."[43] The importance of this was not known until late in the 1950s, when E. S. Kennedy discovered Ibn al-Shatir's models. Kennedy observed that Ibn al-Shatir's models "were mathematically equivalent to those Copernicus elaborated some 150 years"[44] later.

Consequently, the work of Islamic astronomers - that culminated in the work of Ibn al-Shatir - shows that medieval Islamic astronomers did not only translate and preserve the ancient texts of Greek astronomy. They "actually corrected and

37 *Ibid.*
38 *Ibid.*
39 *Ibid.*
40 Charles Coulston Gillispie (ed), *Dictionary of Scientific Biography* (New York: Charles Scriber's Sons, 1976), vol. XI, p.251.
41 King, "The astronomy of the Mamluks," *op.cit.,* p.539.
42 *Ibid.,* p.538.
43 Gingerich**,** *op. cit.*, p.79
44 King, "The astronomy of the Mamluks," *op.cit.,* p.539.

improved on Greek astronomy by creating new mathematical tools to explain the motions of celestial objects."[45] These tools were so useful that Copernicus – according to scholars like Saliba - appears to have borrowed them for use in his heliocentric cosmology.[46] Thus, rather than having declined, Islamic astronomy advanced and culminated in the work of the fourteenth century Syrian astronomer Ibn al-Shatir, whose work played a "fundamental role in the scientific revolution that was forged in Europe during the Renaissance."[47]

Other Astronomical Works under the Mamluks

According to King, amongst other astronomical works, Mamluk astronomers also contributed to instrumentational astronomy. Ibn al-Shatir, for example, not only contributed in theoretical astronomy but also constructed a "magnificent"[48] sundial "set up on a platform on the main minaret of the Umayyad Mosque."[49] Some of the remains of this sundial are now on display in the garden of the Archaeological Museum in Damascus.[50] Another invention of Ibn al-Shatir is "a small universal sundial containing a magnetic compass, which could be set up in the cardinal directions and made functional for any of a series of latitudes in the Mamluk world."[51]

[45] Though this is form the same paper, however this quote is form Saliba's abstract which can be found in American Scientist web sit: http://www.americanscientist.org/articles/02articles/saliba.html
[46] *Ibid.*
[47] *Ibid.*
[48] King "The Astronomy of the Mamluks: A Brief Overview," *op.cit*., p.78.
[49] *Ibid.*
[50] *Ibid.*
[51] *Ibid.*

Others, like Ibn al-Sarraj, made more sophisticated and original astronomical instrumentations. Ibn al-Sarraj devised two kinds of universal astrolabes,[52] which can "perform all operations by using a special rete and a single universal plate."[53] David King only found a manuscript of the treatise on this astrolabe in 1975.[54] Commenting on this astrolabe, King says:

> I consider Ibn al-Sarraj's astrolabe, which is universal from five different aspects, to be the most sophisticated astrolabe from the Near East and Europe in the entire Medieval and Renaissance period.[55]

Furthermore, Ibn al-Sarraj developed different "varieties of markings for the almucantar quadrant and devised various highly ingenious trigonometric grids as alternatives to the simple sine quadrant."[56] Recent research also shows that Ibn al-Sarraj wrote "a major work on instruments, a richly illustrated survey of all varieties of astrolabes and quadrant."[57]

While Ibn al-Sarraj "devised the most successful varieties of instruments," King informs us that such achievements were not limited to him.[58] The instrumentations of other Mamluk astronomers at Cairo and Damascus were also significant.[59] Such astronomers include al-Bakhaniqi, al-Farghani, Ibn Tulun, al-Tizini, Ibn

[52] King, "The astronomy of the Mamluks," *op.cit.,* p.544.
[53] King "The Astronomy of the Mamluks: A Brief Overview," *op.cit*., p.76.
[54] *Ibid.*
[55] King, "The astronomy of the Mamluks," *op.cit.,* p.544.
[56] *Ibid.*
[57] *Ibid.*
[58] *Ibid.* p.545.
[59] *Ibid.*

Sudun, Sibt al-Maridini, Jamal al-Din al-Maridini, Abu Tahir, al-Ghuzuli and al-Waf'i.[60]

In a more recent publication, *Mathematical Instrumentation in Fourteenth-Century Egypt and Syria,*[61] François Charette, provides a critical edition with English translation of a richly illustrated Arabic treatise on the construction of over one hundred various astronomical instruments, many of which are otherwise unknown to specialists. While this work is mainly based on the fourteenth century Najm al-Din al-Misri's treatise, it also benefits from the consultation of a large number of previously unstudied manuscripts, and includes a discussion of all relevant sources from the period 800–1500.[62]

Mamluk astronomers did not only work in the above two areas, but according to King they "worked in each of the major branches of astronomy."[63] Furthermore, astronomers under the Mamluks studies and contributed to different fields of astronomy: theoretical and computational planetary astronomy, spherical astronomy and timekeeping, instrumentation, folk astronomy and astrology.[64]

SUMMARY AND CONCLUSION

The aim of this chapter was to see how far the fate of Islamic astronomy in Syria and Egypt fit with the theoretical claims established in Chapter Four. The chapter

[60] For details of the contributions of these individuals see: King, "The astronomy of the Mamluks," *op.cit.,* p.545-549.
[61] François Charette, *Mathematical Instrumentation in Fourteenth-Century Egypt and Syria* (The Netherlands: Brill Academic Publishers, in print 2003). Available: http://www.brill.nl/m_catalogue_sub6_id11367.htm
[62] *Ibid.*
[63] King, "The astronomy of the Mamluks," *op.cit.,* p.531.
[64] *Ibid.* For details on these types of astronomy see also pages 535-551.

has demonstrated that original astronomical contributions remained quite active through the thirteenth and fourteenth century in Syria and Egypt. Based on insights drawn for King's recent research in astronomy under the Mamluks, the chapter also demonstrated that creative astronomical activity was present after the eleventh century, and only came to an end in Syria with the destruction of Damascus by the Mongols in 1402, and in Egypt with the works of Sibt al-Maridini around 1500.[65] Furthermore, it was highlighted that recent research shows that the astronomical works of the Mamluks "was as impressive as any of their contemporaries in the Near East, where the scientific age was drawing to a close, or in Europe, where a new scientific age was beginning."[66]

These conclusions do not fit with a general decline theory, or with other single-faceted suggestions. They fit well with Ibn Khaldun's theory, which stipulate that: science and scientific instruction existed in other Muslim land like Egypt at a time when they ceased in certain places and were transplanted in others. Furthermore, this case study, like the ones before it, re-affirms Sabra's suggestion that not all centres of scientific activity in the Islamic Empire were always in the same phase of development at the same time. Decline in one branch of science may coincide with progress in another.[67] It also reinforces Saliba's proposition that it is not possible to make generalised conclusions about the fate of Islamic science before it is known what happened to which science, at what time, under what political, economic and social reasons.[68]

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[65] *Ibid*., p.551.
[66] *Ibid.,* p.552.
[67] A. I. Sabra, "The appropriation and Subsequent naturalisation of Greek science in Medieval Islam: A Preliminary Statement," *History of Science*, 25, 1987, p.239.
[68] George Saliba, "Arabic Science Historian George Saliba Rejects Common Explanations of Decline of Science in Islamic World," *Columbia News Video Brief*, July 1 2002.

The next chapter constitutes the last case study of the practical aspect of this thesis. It examines the fate of medicine in Syria and Egypt between the eleventh and sixteenth-centuries to see how far it fits with the four theoretical claims made in Chapter Four.

http://www.columbia.edu/cu/news/media/02/georgeSaliba/. These arguments can also be found in George Saliba, *The Origin and Development of Arabic Scientific Thought*, [Arabic] (Balamand University, 1998), p.14, pp.163-189, and p.190.

8

THE FATE OF ISLAMIC MEDICINE IN EGYPT AND SYRIA BETWEEN THE ELEVENTH AND SIXTEENTH CENTURIES

INTRODUCTION

Chapter Seven has demonstrated that the fate of astronomy in Syria and Egypt does not fit with a general decline theory. Instead, it re-enforces Ibn Khaldun's observations that: science and scientific instruction *existed* in other Muslim land like Egypt at a time when they ceased in certain places and were transplanted in others. It also re-enforces Saliba and Sabra's suggestions that decline of one branch of science may coincide with progress in another, and that much specific research is needed before general conclusions are made. This chapter will examine the fate of medicine in Syria and Egypt between the eleventh and sixteenth centuries to see how far it fits with the four theoretical claims described in Chapter Four. Much of this chapter draws extensively on the work of Dr. Emilie Savage-Smith. As one of the leading historians of medieval Islamic medicine, Dr. Savage-Smith has written extensively about the history of anatomy, surgery, dissection, pharmacy and ophthalmology.[1]

[1] Some of her work includes: "Europe and Islam" in Irvine Loudon (ed), *Western Medicine: An Illustrated History* (Oxford: Oxford University Press, 1997) pp. 40-53; "Medicine," in Roshdi Rashed (ed.) *Encyclopedia of the History of Arabic Science*, vol. 3. (London: Routledge, 1996). , pp. 903-962; "The Practice of Surgery in Islamic Lands: Myth and Reality," in P. Horden and E. Savage-Smith (eds), *The Year 1000: Medical Practice at the End of the First Millennium*, [*Social History of Medicine*, XIII,2] (Oxford: Oxford University Press, 2000), pp. 307-321; "The Exchange of Medical and Surgical Ideas between Europe and Islam," in J.A.C. Greppin, E. Savage-Smith, and J.L. Gueriguian (eds), *The Diffusion of Greco-Roman Medicine into the Middle East and the Caucasus* (Delmar, NY: Caravan Press, 1999). pp. 27-55.

This chapter is organised in the following manner. Section one explains how Islamic medicine is scientific. Section two describes the Islamic tradition of medicine under the Ayyubids and Mamluks patronage, with emphasis on the scientific contributions of the Islamic physician Ibn al-Nafis and the Jewish physician Musa Ibn Maymun (Maimonides). Section three briefly describes the contributions of other physicians who flourished between the eleventh and sixteenth-centuries. The final section offers concluding remarks about the fate of Islamic medicine between the eleventh and sixteenth-centuries.

1. How Islamic Medicine Is Scientific?

It was said in Chapter Two that medicine is particularly difficult as a theorising science because of the complexity of its subject matter. In early primitive societies the techniques that were used were based upon rational religious basis about evil spirits or have intelligible roots in systematic magic. The skills required to learn these crafts were often passed on from father to son, and not learnt from books or a college curriculum. Hippocrates (around 400 BC) was the first to make a systematic expounding of the practice of medicine as a rational art. The fact that his writings became public knowledge was a decisive step forward in the development of scientific medicine, because it encouraged the publication of new observations, new techniques and new theories. From the Hippocratic tradition arose the extensive and competent medical technique of the Roman Empire. The most important figure of that time was Galen (AD 131-200), whose work in

"Attitudes Toward Dissection in Medieval Islam," *Journal of the History of Medicine and Allied Sciences*, 50, 1995, pp.68-111.

medicine was an authority for the next 1300 years. Galen was an outstanding investigator, who is considered as the founder of the science of anatomy. This Hellenistic medicine was passed into the Islamic Empire, where Galen's work was criticised and drastically improved.

It was also said that Islamic medicine was built on tradition, mainly the theoretical and practical knowledge developed in Greece and Rome. Basing themselves upon the Arabic translations of these texts, the Arabs produced new medical knowledge. It was also stated that the novelty of Islamic medicine lie in the way it helped "medicine to become established as a science."[2] Translations of Arabic medical manuscripts gave a decisive direction to the teaching of medicine in the West. After the rather rapid assimilation[3] of the medicines of previous civilisations, Islamic medical writings became "more systematic and synthetic, with an evident urge to produce the most comprehensive and complete medical reference work yet written."[4] A primary concern of Islamic medical scholars was the "organisation of the vast body of knowledge into a logical and accessible format."[5] They also expanded theoretical discourses on causes and symptoms, and frequently introduced examples and procedures of an applied character.[6] A considerable body of medical works were being taught systematically. Great hospitals were founded in major Islamic cities, where the teaching of medicine went on along with the care for the sick. It was in this historical background that Islamic medicine developed and advanced to become scientific.

[2] Danielle Jacquart, "The influence of Arabic medicine in the medieval West," in Roshdi Rashed (ed), *Encyclopaedia of the history of Arabic sciences* (London: Routledge, 1996), vol.3, p.963.
[3] Savage-Smith, Emilie, "Medicine," in Roshdi Rashed (ed), *op.cit.*, p.913.
[4] *Ibid.*
[5] *Ibid.*
[6] *Ibid.*

Certainly, physicians are not the same as scientists. Some physicians do research but are not scientists at all. Others re-write and codify the work of other physicians. Arguably this can be considered part of science. However, the most important scientific work carried out by physicians will be by those who do original work: that is, they identify new illnesses, or theories about the functions of the body, or identify new courses for diseases. Therefore, the number of physicians does not by itself point to the standard of science. The writing of major medical works, and forwarding of new scientific theory by physicians can be used as an indicator of the state of science.

Contrary to popular belief, basic sciences were highly developed in Islamic medicine. Oriental historians of Medicine have erroneously emphasised that science of anatomy, during the Islamic era was undeveloped, and did not progress much further than the discoveries already made and described by the Greeks or 'the ancients.'[7] It was popularly believed that the Islamic physicians did not challenge the anatomic concepts of the 'ancients,' but relied heavily on observations of Galen other Greek sources.[8] However, after recent discoveries of manuscripts by an Egyptian Physician, Muhyi al-Din al-Tatawi (see later), it has become evident that Islamic physicians possessed excellent knowledge of anatomy, and added some challenging new concepts that were revolutionary to the understanding of the 'ancients.'[9] The example that has now become well known is that of the discovery of the lesser, or pulmonary, circulation by Ibn Nafis (whose

[7] Husain F.Nagamia, "Islamic Medicine: History and Current Practice,." *International Institute of Islamic Medicine.* http://www.iiim.org/. (21 October 2003).
[8] *Ibid.*
[9] *Ibid.*

work is discussed later in this chapter). The description given of the pulmonary circulation by Ibn Nafis challenged the fundamental concept held by Galen.

2. The Islamic Tradition Of Medicine Under The Ayyubids And Mamluks

Egypt and Syria had started a tradition of medical care right from the eighth century[10] when the Umayyad Caliph, al-Walid I, created the first known hospital in Islam in Damascus in 706.[11] Al-Nuri Hospital was the most important hospital built in Damascus in the Middle Ages, and in 1156 it was named after King Nur Al-Din Zangi. The Abbasid governor of Egypt Ahmad ibn Tulun built the first hospital in 872.[12] It is the earliest for which there is clear evidence that care for the insane was provided.[13] In the twelfth century, Saladin founded the Nasiri hospital in Cairo.[14] In 1284, al-Mansuri hospital was completed, and surpassed the Nasiri hospital in size and importance.[15] The Mansuri hospital remained the primary medical centre in Cairo throughout the fifteenth century.[16] Al-Mansuri hospital had beds for few thousand patients, different wards specified for different illnesses, and separate male and female quarters.[17] The Nuri hospital in Damascus

[10] G. Hussein Rassool, "The crescent and Islam: healing, nursing and the spiritual dimension. Some considerations towards an understanding of the Islamic perspective on caring," *Journal of Advanced Nursing*, 32, 6, 2000, p.1476.
[11] *Ibid.* Nevertheless, "the first real hospital with all the required facilities of that day was established by Harun al-Rashid in Baghdad during the 8th century, and the Christian physician Jibr'il ibn Bukhtishu' was called from Jundishapur to head it." Seyyed Hossein Nasr, *Islamic Science: An illustrated Study* (World of Islam Festival Publishing Co., 1976), p.155.
[12] Emilie Savage-Smith, 'Medicine,' *op.cit.*, p.934.
[13] *Ibid.*
[14] *Ibid.*
[15] *Ibid.*
[16] *Ibid.*
[17] Nasr, o*p.cit*., p.155.

remained the major hospital well into the fifteenth century, by which time the city contained five additional hospitals.[18]

Mamluk rulers supported and financed the advancement of medicine and the building of hospitals from the revenues of charitable trusts called *waqfs*,[19] or endowments. These were properties donated by wealthy men, especially rulers, whose revenue was used for the building and maintenance of hospitals,[20] and at times some small stipend would be given to patients upon leaving the hospital.[21] While hospitals served as teaching institutions, little is known of how many hospitals provided such an environment.[22] Nevertheless, it is certain that the existence of hospitals in Syria and Egypt in the twelfth century made these cities, especially Cairo, centres of attraction for physicians from everywhere.[23]

There is insufficient information about the number of medical practitioners in medieval Islamic cities, but it has been estimated that in the year 931 Baghdad had one physician per 300 inhabitants.[24] The number of physicians that flourished under the Mamluks is not known. However, one work of the thirteenth century Syrian physician, Ibn 'Abi Usaybi'a, documents the biographies of over 380 physicians.[25] Saladin alone had not less than eighteenth physicians in his service;[26] eight were Muslims, five Jews, four Christians and one Samaritan.[27]

[18] Savage-Smith, 'Medicine,' *op.cit.*, p.934.
[19] *Ibid*. p.935.
[20] *Ibid*. p.935.
[21] *Ibid*. p.936.
[22] *Ibid*.
[23] Nasr, o*p.cit*., p.180.
[24] Savage-Smith, 'Medicine,' o*p.cit.*, p.936.
[25] *Ibid*. p.932.
[26] *Ibid*. p.931
[27] *Ibid*.

More importantly, qualitative original work of a number of scholars are known and documented in contemporary scholarship. Amongst such physicians was Ibn al-Nafis and Maimonides. The works and contributions of these will be examined here.

MEDICAL CONTRIBUTIONS OF IBN AL-NAFIS (1213-1288)

The Syrian physician Ibn al-Nafis, better known in the Arabic literature as al-Qurashi, was an authority on religious law, logic, and theology, as well as a prolific writer of medical tracts.[28] He was also known as 'the second Ibn Sina.'[29] Ibn al-Nafis studied medicine under the famous physician al-Dakwar,[30] and served as the Chief Physician of the Nasiri Hospital in Cairo. As part of his will, Ibn Al-Nafis donated his house, library and clinic to the Mansuri Hospital in Cairo.[31] He died in Cairo in 1288.[32] His approach comprised writing detailed commentaries on early works, critically evaluating them and adding his own original contribution. Ibn Al-Nafis made major contributions to medicine. He is particularly famous for the discovery of the pulmonary circulation,[33] and was the first to describe the constitution of lungs, bronchi, and the coronary arteries.[34] He wrote detailed commentaries and critiques on the medical knowledge available up to his time, and added to it many original contributions.

28 *Ibid*. p.932.
29 Nasr, o*p.cit*., p.180.
30 Ayman O.Soubani and Farouque A. Khan, "The discovery of the pulmonary circulation revisited," (New England Medical Center: Tufts University Scholl of Medicine). *www.kfshrc.edu.sa/annals/152/mh9422ar.html.*
31 *Ibid.*
32 *Ibid.*
33 Savage-Smith, " Medicine," o*p. cit*. p.932.
34 Ayman O.Soubani and Farouque A. Khan, o*p.cit.*

Amongst his works is his attempt to write an enormous compendium of medical knowledge called *al-Shamil fi al-Tibb*.[35] This was an encyclopaedia comprising three hundred volumes, of which he completed only eighty.[36] Amongst his other writings is his *Reference Book for Physicians*, *Polished Book on Ophthalmology*, *Commentary on Hippocrates*, *Epidemics*, *Commentary on Materia Medica* and *Compound Drugs*.[37] One of his most important works *is Commentary on the Anatomy of the Canon of Avicenna* (*Sharh al-Qanun*),[38] which is considered "one of the best scientific books of all times, in which Ibn al-Nafis describes subjects in anatomy, pathology and pharmacology."[39] This book "became an authoritative work in its own right."[40] The Egyptian Physician Muhyi al-Din al-Tatawi[41] discovered this important work of Ibn al-Nafis in 1924 in the Prussian State Library in Berlin.[42]

Ibn al-Nafis's most notable contribution was in the field of human anatomy. He explicitly described the formulation of the pulmonary circulation, which was made three centuries before it was known in Europe.[43] Ibn al-Nafis rejected Galen's assertion that blood "flowed through the septum, the fleshy membrane separating the two ventricles of the heart."[44] Ibn al-Nafis postulated that the blood

[35] Savage-Smith, " Medicine," o*p. cit*. p.932.
[36] *Ibid*.
[37] Ayman O.Soubani and Farouque A. Khan, o*p. cit.*
[38] *Ibid* and Savage-Smith o*p.cit*., p.932.
[39] Ayman O.Soubani and Farouque A. Khan, o*p. cit.*
[40] Savage-Smith, o*p. cit*. p.932.
[41] Nasr, o*p.cit*., p.180.
[42] Ayman O.Soubani and Farouque A. Khan, o*p. cit.*
[43] *Ibid*.
[44] David Goodman and Colin A. Russel, *The Rise of Scientific Europe: 1500-1800* (Kent: Hodder & Stoughton, 1991), p.27.

moves through the lungs, instead.[45] He, therefore, "unequivocally proposed the pulmonary circuit."[46] This is evident in his statement:

> When the blood in this cavity [the right] has become thin, it must be transferred into the left cavity, where the spirit is generated. But there is no passage between these two cavities, and the substance of the heart there seems impermeable... It must, therefore, be that when the blood has become thin, it is passed into the pulmonary artery to the lung, in order to be dispersed inside the substance of the lung, and to mix with the air. The finest parts of the blood are then strained, passing into the pulmonary vein reaching the left of the two cavities of the heart.[47]

The discovery of the pulmonary circulation can be fixed at 1242, three hundred years before the work of Servetus and Colombo.[48] Initially, Andrea Alpago (d.1520) of Belluno translated some of Ibn al-Nafis's works to Latin in 1547.[49] Alpago lived mainly in Syria for thirty years or so, during which he was collecting, translating and editing the writings of Islamic physicians.[50] He made a Latin translation of part of Ibn al-Nafis' *Sharh al-Qanun* wherein he makes "some interesting statements on the Galenic doctrine related to the heart and arterial system, together with Ibn al-Nafis' criticism."[51]

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[45] *Ibid*
[46] Roy Porter, "Heart and soul," *New Scientist*, 170, 2290, May 12, 2001, p.50
[47] Charles Coulston Gillispie, *Dictionary of Scientific Biography* (New York: Charles Scribner's Sons, 1974), vol. IX, p.603.
[48] *Ibid.*
[49] E. D. Coppola, "The discovery of the pulmonary circulation: A new approach," *Bulletin of the History of Medicine*, 31, 1957, pp.44-77.
[50] Gillispie, *Dictionary of Scientific Biography*, o*p. cit*, p.604.
[51] *Ibid.*

In 1553, Michael Servetus described the pulmonary circulation in his theological book *Christianismi Restitutio*.[52] In his book *De Favrica*, Andreas Vesalius described the pulmonary circulation in a manner similar to Ibn al-Nafis.[53] In 1559 Realdus Colombo gave a similar description in his book *De re Anatomica*.[54] Eventually, in 1628 William Harvey demonstrated the description of the circulation of the blood by direct anatomic observation in laboratory animals the physiology of the pulmonary circulation[55] – to which this discovery is generally attributed. He published his results in *Exercitatio anatomica de motu cordis et sanguinis in animalibus*[56]

Recent research acknowledges Ibn al-Nafis as the first to discover the pulmonary circulation. For example, some forty years ago, both Marie-Therese d'Alverny and Joseph Schacht collected evidence to support the thesis that the discovery of the pulmonary circulation of the blood can first be documented in a thirteenth-century work of Ibn al-Nafis, and was later rendered in the Latin texts of the Renaissance by the sixteenth-century physicians Servetus and Colombo before it was finally reformulated, with some additions by Harvey. [57] Mieli believes that "it is fair to attribute the discovery of the pulmonary circulation to Ibn al-Nafis who was a distant precursor of the physicians of the sixteenth century Italian School

[52] C. C. Mettler, *History of medicine* (Philadelphia: Blakiston Co., 1974), pp.40-59 and pp.113-128.
[53] *Ibid.*
[54] *Ibid.*
[55] E J Gordon, "William Harvey and the circulation of the blood," *South Medical Journal*, 84, 1991, pp.1439-44.
[56] G. C. Cook, "Does history repeat itself in medicine?" *Postgraduate Medical Journal*, 77, 906, Apr 2001, p.263-
[57] George Saliba*,* The "Arabick" Interest of the Natural Philosophers in Seventeenth-Century England," (book reviews), *The Journal of the American Oriental Society*, 117, 1, Jan-March 1997, p.175(3).

and of William Harvey who, four centuries later, described the whole of the pulmonary circulation in an accurate, clear and definitive manner."[58]

Buchs says that the discovery of the book *Commentary on the anatomy of the Canon,* allows the attribution of the description of lung circulation to Ibn al-Nafis,[59] but the new discovery of the little circulation in the sixteenth century was independent from the one in thirteenth century.[60] However, "if it is not still possible to specify the exact itinerary of this discovery, we have reason to think that the work of Ibn al-Nafis was the primary source of the rediscovery of the lung circulation in the sixteenth century."[61] Persaud reinforces this opinion stating that "from manuscripts that were rediscovered and translated in 1924 we now know that Ibn al-Nafis (1210-1288) of Damascus" had made the same observations as Michael Servetus (1511-1553) three centuries earlier.[62] Porter also states that the discovery of the pulmonary circulation is normally attributed to William Harvey, but the person who rightly deserves recognition is the thirteenth century Arab physician Ibn al-Nafis, whose proposal of the pulmonary circuit was forgotten and remained unpublished until the twentieth century.[63]

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[58] S. A. Al-Dabbag, "Ibn al-Nafis and the pulmonary circulation," *Lancet*, 1, 1978, p.1148.

[59] M. Buchs, "History of a discovery: Ibn al-Nafas and the lung circulation," *Med Secoli*, 7, 1, 1995, pp.95-108.

[60] *Ibid.*

[61] *Ibid.*

[62] T. V. Persaud, "Historical development of the concept of a pulmonary circulation," *Canadian Journal of Cardiology*, 5,1, Jan-Feb 1989, pp.12-6. Also see: L.A Abdul-Aziz, "Does history repeat itself in medicine?" *Postgraduate Medical Journal*, 77, 913, 2001, p.743. E. Kahya , "Ibn al-Nafis and his work Kitab Mujiz al-Qanun," *Studies in the History of Medical Science*, 9,3-4, 1995, p.89-94. S. Y El-Gammal, "Therapy and medicaments by Ibn al-Nafis," *Bull Indian Inst Hist Med Hyderabad*, 22, 2, July 1992, pp.111-20. Savage-Smith, "Ibn al-Nafis's Perfected book on ophthalmology and his treatment of trachoma and its sequelae," *J Hist Arabic Sci*., 1980, 4, pp.147-204. F. Saidi "Ibn Al-Nafis," *Journal of the Royal Society of Medicine*, 91, 9, 1998, p.508. P. Ghalioungui , "Was Ibn al-Nafis unknown to the scholars of the European Renaissance?" *Clio Med*., 18, 1-4, 1983, pp.37-42.

[63] Roy Porter, "Heart and soul," *New Scientist,* 170, 2290, 2001, pp.50-

Ibn Al-Nafis' works integrated the then existing medical knowledge and enriched it, thus exerting great influence on the development of medical science, both in the East and the West. Thus, according to Savage-Smith, "it seems likely" that Ibn al-Nafis's work "did influence European anatomical theories."[64]

MEDICAL CONTRIBUTIONS OF MUSA IBN MAYMUN (MAIMONIDES) (1135-1204)

Abu 'Imran Musá ibn 'Ubayd Allah ibn Maymun al-Qurtubi (d. 1204) was a medieval Jewish polymath - philosopher, theologian, and physician - who is generally known by his Greek name Maimonides.[65] Maimonides was born in Cordova, Spain, in 1135. After a sojourn in Morocco, the family finally settled in Cairo in 1165. Tragedy struck when both Maimonides' father and brother, David, died within the same year. Faced with the task of providing for David's family, he turned to the practice of medicine. Until then his life had been noticeable because of his exceptional scholarly achievement in the fields of theology, philosophy, and ethics.[66]

A study of his medical works reveals a holistic approach to the patient.[67] Although drawing on Hippocrates and Galen, Maimonides elaborated a framework in which "explicit emphasis is placed on biological, psychosocial, and social factors in both

[64] Emilie Savage-Smith, "Medicine," o*p. cit*., p.951.
[65] Howard R. Turner, *Science in Medieval Islam: An Illustrated Introduction* (Austin: University of Texas Press, 1995), p.137.
[66] Sidney Bloch, "Moses Maimonides' contribution to the biopsychological approach in clinical medicine," *The Lancet*, 358, 9284, Sept 8, 2001,p.829.
[67] *Ibid*

health and ill health."[68] In his approach, Maimonides considers: Overall human function, biological dimension, psychological dimension, social dimension, and implications for treatment. And his methods of treatment include: behavioural, cognitive, and insight-oriented.[69]

His outstanding clinical skills earned him a widespread reputation, so much so that he was appointed physician to Saladin.[70] And despite being very busy he, like many of his contemporaries, succeeded in learning about a range of topics from toxicology to asthma.[71] He wrote ten works in all, including Regimen Sanitatis[72] published in 1200; a text that embodies the essence of the biopsychological approach. He died in 1204 aged 69 years.[73]

Regimen Sanitatis, also known as "The preservation of youth," was prepared in 1198-1200 for a distinguished patient, al-Malik al-Afdal, Saladin's eldest son.[74] This work covered an immensely broad area including "therapeutic, preventive, and health promotional."[75] The first of the four sections deals with diet relying on Hippocrates and Galen.[76] His second chapter encompassed a range of topics in which Maimonides "examines the relative roles of nature and physician in recovery from illness."[77] And he also "hints at a psychological dimension in the overall treatment. In his final chapter he emphasises the importance of fresh air,

[68] *Ibid*
[69] *Ibid*
[70] *Ibid*
[71] *Ibid*
[72] M. Maimonides, *Regimen Sanitatis: the preservation of youth--essays on health* (New York: Philosophical Library, 1958).
[73] Bloch, o*p.cit.*
[74] *Ibid*
[75] *Ibid*
[76] *Ibid*
[77] *Ibid*

sunshine, and quality of food, and also comments on bathing and sexual practice."[78]

Recent research in this work of Maimonides suggests that amongst his contributions to modern medicine "was to combine social factors with biological and psychological ones as aspects of health."[79] Furthermore, Maimonides discussed "the importance of proper nutrition and personal hygiene to maintaining good health."[80] And it is believed that he "pioneered discussion of what is today called 'mind-body' connection, i.e., how psychological conditions can affect physical ones."[81]

More recent research suggests that Maimonides contributed to the history of medical ethics and deontology. Thus, according to Pavlovic Maimonides was "the first after Hippocrates to write a text of a "prayer" he spoke out at the beginning of his medical profession – i.e. when he took oath. The text of "Maimonides's prayer" is today obligatory in some schools of medicine in the United States of America."[82]

Maimonides medical aphorisms dealt with almost all aspects of health and disease. Galen, to whose contributions he added new dimensions, influenced his

[78] *Ibid*
[79] *Ibid*
[80] *Ibid*
[81] *Ibid*
[82] B. Pavlovic, " Maimonides, a physician in the 12 century. Contribution to the history of medical ethics and deontology" [Article in Serbo-Croatian (Cyrillic)], *Srp Arh Celok Lek*, 128, 5-6, 2000, May-Jul, pp.225-8.

aphorisms on urine and the kidney. Maimonides aphorisms dealt with a variety of renal diseases recognised today.[83]

3. Various Other Medical Achievements

Syria and Egypt boasted of many other physicians (too numerous to examine here). The following is a brief sketch of the important work of some of these physicians.

In the field of *materia medica* and its applications, not only did Islamic writers surpass their earlier models but also the preparation and use of medicinal drugs was a topic that also had its own specialised literature.[84]Initially, knowledge of medicinal substances was based upon the approximately 500 substances described in the first century by Dioscorides in his Greek treatise on *materia medica*.[85] However, many Arabic and Persian treatises were subsequently written on medicaments.

The largest and most popular of *materia medica* manuals was that by Ibn al-Baytar. Ibn al-Baytar was born in Malaga, in the kingdom of Granada, towards the end of the twelfth century and later became 'Chief of Botanists' in Cairo in the first half of the thirteenth century. His Arabic treatise, *The Comprehensive Book on Materia Medica and Foodstuffs* (*Kitab al-Jami` li-mufradat al-adwiyah wa-al-*

[83] S.G. Massry, "Maimonides: physician and nephrologist," *Am J Nephrol*, 14, 4-6, 1994, pp.307-12.
[84] Emilie Savage-Smith, *Islamic Medical Manuscripts at the National Library of Medicine*, http://www.nlm.nih.gov/hmd/arabic/welcome.html
[85] *Ibid.*

aghdhiyah), was an alphabetical guide to over 1400 drug samples of animal, plant and mineral origin[86] taken from his own observations as well as from 150 written sources that he names.[87] His manual formed the basis of many subsequent manuals on medicinal substances.[88] This work "marks a summit in its own field and is the most influential Islamic work on the subject, both within and outside the Islamic world, its influence having even reached Armenia."[89] Ibn al-Baytar's main contributions, however, was "the systematisation of the discoveries made by Arabs during the Middle Ages, which added between 300 and 400 medicines to the thousand known since antiquity."[90]

The topic of poisons was of great interest in both antiquity and the medieval world and Galen and Dioscorides were considered ancient authorities on the subject, and many spurious treatises on the subject were attributed to them.[91] Many Islamic writers discussed poisons and the antidotes for poisons.

One of the most important Arabic treatises on antidotes for poisons was written in 1270 in Syria by Ali ibn Abd al-Azim al-Ansari.[92] In his treatise al-Ansari provides information regarding "medical learning in the Crusader States as well as the plants that the author describes as having been found in Syria at the time."[93] Furthermore, al-Ansari's work contains extensive quotations from other treatises

[86] Nasr, o*p.cit*., p.181.
[87] Wendell E. Wilson, "Antecedents (The History of Mineral Collecting: 1530-1799)," *The Mineralogical Record*, 25, 6, Nov-Dec 1994, p.12 (7).
[88] Emilie Savage-Smith, *Islamic Medical Manuscripts at the National Library of Medicine*, *op.cit.*
[89] Nasr, o*p.cit*., p.181 and Charles Coulston Gillispie, *Dictionary of Scientific Biography*, o*p.cit*., vol. I, p.539.
[90] *Ibid*., p.538.
[91] Emilie Savage-Smith, *Islamic Medical Manuscripts at the National Library of Medicine*, *op.cit.*
[92] *Ibid.*
[93] *Ibid.*

on plants and antidotes.[94] Among these were the writings of the tenth century Egyptian physician al-Tamimi and the Syrian physician Rashid al-Din al-Mansur ibn al-Suri, who died in 1243.[95] Ibn al-Suri is known to have prepared an illustrated herbal with figures drawn from plants he observed on his travels.[96] However, both the illustrated herbal by Ibn al-Suri and the treatise on antidotes by al-Tamimi are lost today, making al-Ansari's citations the only source of information regarding their contents.[97]

Another Syrian physicians is Ibn al-Quff, Abu al-Faraj ibn Muwaffaq al-Din Ya'ub ibn Ishaq (d. 1286). He was born in 1233 in Syria, where his father was a learned court official. He studied medicine with Ibn al-Nafis and with Ibn 'Abi Usaybi'ah.[98] Though a Christian, he became one of the leading thirteenth century physicians in Syria and enjoyed the patronage of the rulers in Syria.[99] He composed a number of treatises, including an important treatise on surgery and a popular commentary on the Aphorisms of Hippocrates.[100] He also composed the only and most important specialised, independent surgical manual, in "which he omitted all ophthalmological procedures because he considered these the province of a specialist."[101] Ibn al-Quff also described making artificial teeth from bone and wrote about complications of haemorrhoidectomy and post-operative anal

[94] *Ibid.*
[95] *Ibid.*
[96] *Ibid.*
[97] *Ibid.*
[98] Another prominent Damascene physician as well as compiler of biographical sketches of physicians.
[99] Emilie Savage-Smith, *Islamic Medical Manuscripts at the National Library of Medicine*, *op.cit.*
[100] *Ibid.*
[101] Emilie Savage-Smith, "Medicine," *Encyclopaedia of the History of Arabic Science*, *op.cit.*, p.943.

stricture.[102] Ibn al-Quff was a famous surgeon whose book *The Basic Work concerning the Arts of Surgery* (*Kitab al-'umdah fi sina'at al-jiraha*) was composed of twenty articles. He is also the first physician to point out "clearly the existence of capillaries which were seen under a microscope for the first time by Malpighii in 1661."[103]

Ibn Jumay' al-Isra'ili Hibat Allah (d. 1198) was a Jewish Egyptian physician born in Fustat (old Cairo). He received honorific titles such as *Ustadh zamanih* ("Master of His Age").[104] Ibn Jumay' became famous for having prevented a person having a cataleptic fit from being buried alive. He was the author of a number of medical writings, including *al-Irshad li-masahih* (*Guidance for the Welfare of Souls and Bodies*), dedicated to al-Baysani, the vizier to Saladin, and completed by Ibn Jumay' al-Isra'ili's son Abu Tahir Isma'il.[105] The medical compendium titled *al-Irshad* is composed of four sections (*maqalahs*). The first is concerned with the general principles of medicine, the second with materia medica, the third with the treatment of diseases, and the fourth with compound remedies.[106]

Ibn Mutran, Muwaffaq al-Din Abu Nasr As'ad ibn Ilyas (d. 1191), was a Christian scholar from Damascus who converted to Islam during the reign of Saladin.[107] He served Saladin as court physician in Egypt, where he attained great wealth and a

[102] Prof. Dr. Omar Hassan Kasule Sr, *Surgery in Islam: A historical and current reappraisal*, http://www.iiu.edu.my/medic/islmed/Lecmed/his-surg98.nov.html
[103] Nasr, *op.cit*., p.181.
[104] Emilie Savage-Smith, *Islamic Medical Manuscripts at the National Library of Medicine*, *op.cit.*
[105] *Ibid.*
[106] *Ibid.*
[107] *Ibid.*

massive library of his own, which contained ten thousand volumes.[108] His most famous work is *The Garden of the Physicians and the Meadows of the Wise* (*Kitab Bustan al-atibba' wa-rawdat al-alibba'*), which is a medical anthology containing quotations and extracts from a large number of early medical writings.[109] For Saladin, he wrote a treatise on regimen (*fi al-tadabir al-sihhiyah*) that is preserved today in a manuscript in Istanbul.[110]

Suwaydi (d. 1292) was a physician and philosopher active in Cairo and in Damascus.[111] He was a pupil of Ibn al-Baytar and a friend of the medical historian Ibn Abi Usaybi'ah.[112] He composed a treatise on synonyms for plant names, a treatise on the medical uses of stones, and a "memorandum book (*Tadhkirah*) in which he recorded recipes and procedures using various medicaments extracted from a large number of Islamic, Greek, and other sources."[113] He arranged the recipes "according to the location of the compliant to be treatises, that is, from head to foot."[114]

Fath al-Din al-Qaysi of Cairo (d.1259) wrote *The Result of Thinking about the Cure of Eye Diseases (Natijat al-fikar fi `ilaj amrad al-Basar*). Al-Qaysi was one of a three-generation family of court physicians in Cairo and was himself 'Chief of Physicians' in Egypt, and physician to two Ayyubid rulers, including

[108] *Ibid*
[109] *Ibid*
[110] Ibid.
[111] *Ibid*
[112] *Ibid*
[113] *Ibid*
[114] *Ibid.*

Saladin.[115] In this treatise, al-Qaysi included seventeen chapters "dealing with the anatomy and physiology of the eye and the causes, symptoms and treatment of 124 eye conditions, some apparently described here for the first time."[116] About a decade later, the Syrian Khalifah ibn Abi al-Mahasin al-Halabi, composed another comprehensive ocular manual that included elaborate charts of instruments.[117] Other ophthalmological manuals were written in Egypt and Syria in the thirteenth and fourteenth centuries, "including a comprehensive survey of ophthalmology by the Syrian epitomiser of Ibn Sina's Canon, Ibn al-Nafis who practiced in both Damascus and Cairo."[118]

SUMMARY AND CONCLUSION

The aim of this chapter has been to examine how far the fate of Medicine in Syria and Eygypt fit with the four theoretical claims recognised in Chapter Four. Contrary to a general decline theory, Emilie Savage-Smith explains that because the Mamluks in Egypt were able to repel the invasion of the Mongols, "the medical community there remained active for a longer period of time than elsewhere."[119] Consequently, the learned medical community remained quite active through the fourteenth century, particularly in Syria and Egypt.[120] But "within two more centuries nearly all traces of serious scholarly activity had faded,"[121] with the exception of Safavid Persia, which continued to "write and

[115] *Ibid*
[116] *Ibid*
[117] *Ibid*
[118] *Ibid*
[119] Savage-Smith. "Medicine," *op.cit.*, p.955-956.
[120] *Ibid.*
[121] *Ibid.*

organise with some degree of originality" through the sixteenth and seventeenth centuries.[122]

This conclusion does not fit with the decline theory, or with other single-faceted suggestions. It fits well with Ibn Khaldun's theory, which stipulate that: science and scientific instruction *existed* in other Muslim land like Egypt at a time when they ceased in certain places and were transplanted in others. It also strengthens Sabra's claim that not all centres of scientific activity in the Islamic Empire were always in the same phase of development at the same time. Decline in one branch of science may coincide with progress in another.[123] The conclusion also reinforce Saliba's proposition that it is not possible to make generalised conclusions about the fate of Islamic science before it is known what happened to which science, at what time, under what political, economic and social reasons.[124]

This chapter marks the last of the practical case studies. Having completed both the theoretical and practical requirements of the thesis, it is clear that; overall, scholarship on the fate of Islamic science has failed to understand and describe what happened. Therefore, a discussion on the quality of scholarship on the fate of Islamic science between the eleventh and sixteenth-centuries will now follow.

[122] *Ibid.*
[123] A. I. Sabra, "The appropriation and Subsequent naturalisation of Greek science in Medieval Islam: A Preliminary Statement," *History of* Science, 25, 1987, p.239.
[124] George Saliba, "Arabic Science Historian George Saliba Rejects Common Explanations of Decline of Science in Islamic World," *Columbia News Video Brief*, July 1 2002. http://www.columbia.edu/cu/news/media/02/georgeSaliba/. These arguments can also be found in George Saliba, *The Origin and Development of Arabic Scientific Thought*, [Arabic] (Balamand University, 1998), p.14, pp.163-189, p.190.

9

A DISCUSSION ON THE QUALITY OF SCHOLARSHIP UNDER QUESTION

INTRODUCTION

To recapitulate, Chapter Four has presented a comprehensive review of scholarship on the fate of Islamic science between the eleventh and sixteenth-centuries. Four major theoretical statements were found, each purports to be realistic, offering some descriptions of what actually happened to Islamic science in the period under study:

1. Ibn Khaldun’s multi-dimensional theory that claims that different fates awaited Islamic science, in different areas and at different times.
2. The influential and persistent decline theory that claims Islamic science went through a golden age in the eleventh century, and then entered a period of more or less uniform decline. The decline theorists would accept the existence of some science after the eleventh century, but would postulate that it was always inferior in both quantity and quality to what had gone before.
3. Non-decline ideas that suggest that Islamic science “decayed,” “froze,” “stagnated,” and that it came to a “standstill.”
4. Finally, the more recent view that rejects the notion of a general decline and states that Islamic science flourished up to the sixteenth century.

Assessment of these claims disclosed that the key problem of the scholarship is that after Ibn Khaldun there was a centuries-long gap, in which even excellent historians used simplistic and dismissive terms and concepts regarding what happened. In addition, many scholars failed to build on the work of others; they ignored major pieces of evidence; and, in most cases, they were not trying to discern what happened to Islamic science but were referring to the subject as part of another project.

Chapters Five, Six, Seven and Eight reviewed and assessed four cases of Islamic science belonging to different geographical regions to see how far they fit with the theoretical claims postulated in Chapter Four. Examination of the evidence for specific areas demonstrated a number of findings. First, Ibn Khaldun's approach appears to be far better to fit the evidence than subsequent claims. Second, certainly there is no evidence of a general decline, and that it is clear that some branches of Islamic science flourished for centuries after the eleventh century. At best, the famous theory of decline is an unconfirmed hypothesis. Third, single-faceted claims – such as "decline," "stagnation," and that Islamic science "frozen" - are simplistic and do not offer an accurate depiction of what happened. Finally, the more recent explanations offered by scholars like Saliba and Sabra mark a return to proper scholarship in the sense that they reject a general decline theory, hint at a more complex solution, and their approach fits the evidence better.

Based upon insights drawn from the theoretical and practical sections of the study, this chapter aims to discuss the reasons for the overall failure of scholarship to explain what happened to Islamic science between the eleventh and sixteenth-centuries. Explanations will consist of a number of hypotheses about the processes occurring at various junctures in the production, reception, assessment, and dissemination of scholarly knowledge. This account owes much to that presented by Richard Hamilton,[1] who examines the social determinant of knowledge. These hypotheses will be supported with evidence gathered in the previous chapters, and at other times will be backed up by understanding of the nature of the scholarly community described in Chapter Three.

This chapter is organised in the following manner. Section one explains the procedural factors that may have led to inadequacies in the scholarship under question. Section two elaborates on the decline theory, particularly the way it persisted, and remains in use, in the absence of compelling empirical evidence. Section three discusses some social psychological factors that may have been instrumental for the persistence of the decline theory. The last section offers concluding remarks about the quality of the scholarship under question.

1. Procedural Factors

Inadequate Scholarship of Research: Failure to Check Text Claims Against Original Sources

Chapter Three has demonstrated that adequate research constitutes one of the most fundamental characteristics of reliable scholarship. Adequate research allows

[1] Richard, F. Hamilton, *The social Misconstruction of reality: Validity and Verification in the Scholarly Community* (New Haven: Yale University Press, c1996).

faulty theories based on mistaken assumptions, or unsustained predictions, to be either repaired or abandoned. Another key task of research is to provide a better understanding of ideas. In short, adequate scholarship of research aids in allowing scholars to distinguish facts from decisions based on consensus, emotions, or traditions. It was also said that one of the assumptions underlying scholarship of research is that through systematic effort information is assessed and errors are corrected. In historical study, a basic requirement is checking of original sources. However, variations may occur in those assessments, ranging from none to considerable. If the review is not adequate, distortion of proper understandings is likely to creep in and continue.[2]

Ideally, as a basic scholarly practice, researchers are supposed to check original sources before they ascertain any hypothesis. However, Hamilton explains that, "one of the most fundamental of the procedural problems in scholarship is the failure to check claims against original sources."[3] Failure to check original sources means that scholars accept the following assumptions on face value: that original evidence actually exists; that the evidence is credible, without problem or difficulty; and that it has been accurately reproduced in all subsequent tellings.[4] Failure to check original sources could lead to the uncritical acceptance of prior scholarly works. This could be either innocent (as with random error) or in some way "motivated," that is to say, the production of some predisposition.[5] Conclusions may be accepted "on assumptions" because of their surface

[2] *Ibid.,* p.8.
[3] *Ibid.,* p.205.
[4]*Ibid,* p.17.
[5] *Ibid.*, p.25.

plausibility, there being no immediate grounds for doubt. Alternatively, they may be accepted because they agree with prior training or preference.[6]

Systematic authentication by means of scholarly research can produce pure knowledge. Scholarship based on assumptions, and devoid of facts, is likely to produce pure myth. The crucial distinction in a scholarly work, therefore, is one of procedure, not of end result.[7] There is a fine distinction to be made here. Both genuine scholarship of research and consensual approval may look the same. However, one comes from a process of research, criticism and debate, the other simply from accepting pre-existing ideas.

Hence, one key aspect of the explanation for the failure to provide complex theories and ideas regarding the fate of Islamic science must focus upon the simple fact that many scholars failed to conduct adequate research. A basic rule of scholarly practice demands that wherever possible one should go to original sources. However, most of the scholarship under question failed to go to original sources, which has ultimately led to a failure to provide substantial evidence to support given hypotheses. For example, six centuries after Ibn Khaldun had postulated his theory, but many eminent historians and scholars, old and new, (such as Sarton, de Vaux, Meyerhof, Hitti, Huff, McClellan III and Dorn, and many others) demonstrated no awareness of it. To cite but one example, consider Carra de Vaux's statement that intellectual activity ceased in the Islamic world, but "no one has yet put forward any very definite theory"[8] to explain the reason

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[6] *Ibid.*
[7] Thomas Sowell, *Knowledge and Decisions* (New York: Basic Books, 1980), p.4-5.
[8] Baron Carra de Vaux, "Astronomy and mathematics," in Sir Thomas Arnold and Alfred Guillaume(eds), *The legacy of Islam* (Oxford: Clarendon Press, 1931), p.397.

behind this cessation. If the basic research were undertaken, de Vaux would have realised that Ibn Khaldun offered a definite theory six centuries earlier describing what happened, and why. Ibn Khaldun does declare that in some parts of the Islamic world Islamic science ceased to exist, but certainly he did not claim that this cessation was uniform across all disciplines and regions. Ignorance of Ibn Khaldun's theory is a serious mistake on the part of many scholars. Accordingly, it can be safely assumed that this mistake must have led to an all-inclusive, one-dimensional understanding of what happened to Islamic science.

Only Von Grunebaum and al-Hassan showed familiarity with Ibn Khaldun's theory. Unfortunately, both scholars inadequately represented it. Again, this failure, it can be assumed, must have been instrumental in Von Grunebaum's all-inclusive and one-dimensional description of what happened. As for al-Hassan, this failure did not effect his overall conclusion, primarily because he (unlike Grunebaum) relies on up-to-date evidence to support his claim that Islamic science flourished up to the sixteenth century. Thus, al-Hassan, while not attempting to propound a general theory, provided useful material for a general theory.

Certainly, a thoughtful reading of Ibn Khaldun's theory, or original texts on Islamic science, would have forced rejection, or alteration, of all single-dimensional claims, including the much vouched for decline theory. Adequate research would have shown the falsity of the idea that Islamic science failed to flourish after the eleventh century. Inadequate research, however, allowed simplistic claims to persist for centuries, and delayed their rejection by scholars like Saliba.

There were some scholars who researched original sources. But, contrary to evidence, they clung to the handed-down theory of decline (like Sarton, Sayili, Huff and Lindberg). In these cases, two processes may have been involved: a simple reworking of the old mythology, and an easy acceptance of the probable (because it is so often repeated) framework even in the face of contrary evidence. Sayili and Huff, for example, provided new evidence to dispel the notion of decline, but this did not change previous assumptions, the handed-down claim of decline remained in their views as valid as ever.

Some other scholars failed to research secondary evidence, let alone primary texts. Hoodbhoy, for example, claimed that Islamic science declined, but failed to show familiarity with research that might have strengthened his own arguments. In fact:

> Of all the publications by dozens of specialist historians, only a single article by A.I. Sabra is cited, and then only in support of the obvious point that Nestorian Christians played a major role in translating Greek texts into Arabic.[9]

Additional insight into the inadequacies of scholarly research may be gained through consideration of the availability of evidence that began to appear subsequent to the formulation of many a single-faceted claim. For example,

[9] Roderick Grierson, "Islam and Science: Religious Orthodoxy and the Battle for Rationality." (book reviews) *New Scientist*, 134, 1815, April 4, 1992, p.45 (2).

Chapter Two explained that an unprecedented acceleration of research in Islamic science started from the 1950s onwards. E.S. Kennedy and his students at the American University of Beirut rediscovered Ibn al-Shatir's forgotten model in the late 1950s. The discovery made scholars realise that Ibn al-Shatir's inventions, were the same type of mechanism used by Copernicus few centuries later. This is but one example of the evidence that could have easily been applied to dispel many simplistic notions of the fate of Islamic science. But many scholars ignored it.

Hitti, for example, proposed his single-faceted and simplistic claim in 1968, Saunders in 1977, Elena in 1987, and Qadir in 1988. In 1992, Lindbergh still believed that Islamic science declined "during the thirteenth and fourteenth centuries: by the fifteenth century, little was left."[10] In 1999, McClellan III and Dorn asserted, "others say that important new science continued to be done in the East until the fifteenth and sixteenth centuries,"[11] but Islamic science reached its heights in "the centuries surrounding the year 1000 and that decline in the creative level of original work eventually set in."[12] Considering the availability of evidence by their time, such conclusions are preposterous. The availability of relevant evidence provided an appropriate "experimental condition"[13] to challenge many received claims. It is an important scholarly practice that one must report relevant evidence, whether favourable or not, with any given claim. In actual fact, this was completely neglected in most of the scholarship under question.

[10] David C. Lindberg, *The Beginning of Western Science: The European Scientific Tradition in Philosophical, religious, and institutional Context, 600 B.C. to A.D. 1450*," (Chicago: The University Chicago Press, 1992), p.180.
[11] James E. McClellan III and Harold Dorn, *Science and Technology in World History* (Baltimore and London: The Johns Hopkins University Press, 1999), p.113.
[12] *Ibid.*
[13] Hamilton, o*p.cit*., p.166

Nevertheless, more adequate research began to emerge in the more recent works of scholars like al-Hassan, Sabra and Saliba. Based on substantial evidence from the history of Islamic science, these scholars began to reject, or offer complex solutions to, the conventional idea that Islamic science suffered a homogeneous fate. Though they did not offer alternative theories, some of them were cautious not to draw overall conclusions about what happened (particularly al-Hassan and Saliba). Sabra even recommended that different fields of Islamic science must be studied, in different contextual settings, before overall conclusions are drawn.

Inadequate scholarship of research that persisted for a long time, then, leads to a certain conclusion: with the exception of scholars like al-Hassan Sabra, and Saliba, the claims made regarding the fate of Islamic science are at best a set of hypotheses with rather doubtful empirical foundations. This highlights a serious problem in the scholarship: for a long time, these simplistic schemes were sustained without any serious review of sources or, at minimum, without any successful challenge to the widespread agreement about facts or interpretations that were mistaken (as in the decline theory). If undertaken, research would have yielded some striking instances of non-support for one dimensional claims, particularly the long held decline theory and, on the basis of what is now know, an absence of compelling supporting evidence.

It can be hypothesised that a number of factors caused the failure of the scholarship of research under question, including: concern with the “inner logic” of a claim, and not the realism of initial assumptions; inability to access an adequate record of Islamic science in the way of institutional resources, libraries, collections of manuscripts; basing decisions on assumption that has not been tested with evidence; conformity to given viewpoint contrary to evidence; basing decisions on consensual approval; and low level of research in the Arab world.

A. Concern with the "inner logic" of a claim, and not the realism of initial assumptions.

Chapter Three has stated that the main objective of research is to verify specific claims, arguments, and theories, and not accept these on face value. In any given case, a scholar must question the accuracy of initial assumptions, and must attempt to discover, via research, empirical support for claims. In reality, however, this does not always happen. There is always a possibility that scholars may attempt to work out the "inner logic" of a set of initial assumptions with high surface probability, and not the realism of the first principles themselves. Of course, there is nothing wrong with spelling out the "inner logic" of a claim. The problem arises when the results of this inner logic are not compared to evidence. Indeed, one can argue that an important aspect of scholarship is spelling out the implications of ideas. However, there must then be some kind of comparison with reality.

The review of scholarship in Chapter Four provides ample evidence to confirm that many scholars were concerned with the "inner logic," and not the realism, of first principles. To illustrate: many decline theorists failed to question the realism of the initial assumption of decline, accepted it on face value, and ventured into offering casual explanations for a supposed decline. Whether it was Renan, Sarton, Sayili or Huff, their approach was one of finding explanations for the reasons behind the decline of Islamic science. There is no evidence to suggest that they questioned the notion of decline, even when contrary evidence was available. Sayili and Huff, for instance, failed to question the notion of decline even though they had enough evidence to do so. Consequently, this approach - the concern for the inner logic and not the realism of initial assumptions - must have curtailed recognition of a basic fact: the initial principles of the different claims are problematic, which in turn hindered adequate research.

B. Inability to access an adequate record of Islamic science in the way of institutional resources, libraries, collections of manuscripts, and the like

Another possible reason behind the inadequacy of the scholarship of research is the inability to access an adequate record of Islamic science in the way of institutional resources, libraries, collections of manuscripts, and the like. This is, perhaps, due to a number of factors: scholars often do not read the language of original text, the absence of an adequate record, the failure to understand science, or a combination of these.

The unavailability of an adequate record of Islamic science can cause a real problem for scholarship. This is particularly true considering the fact that the history of Islamic science, as a field, "hasn't even begun yet."[14] In Chapter Two, it was noted that in the last few decades a significant number of excellent studies by competent historians of Islamic science has led to a qualitative shift in our

[14] Dennis Overbye, "How Islam won, and Lost, the lead in science," *Science Times*, October 30, 2001.

understanding of this history, yet there are thousands of original manuscripts not touched as yet.

On the other hand, a scholar may have access to original text, and may understand the language, but may still produce inadequate knowledge. This was clearly demonstrated in Chapter Three in the case of Dr Sulaiman, who published a translation of al-Tusi's book called *Tadhkira.* According to Saliba, he approached the text from a linguistic perspective, assuming that since the text is in Arabic, then being able to understand Arabic would make it possible for him to understand the text on his own. But, due to his lack of expertise in the subject matter, and the importance of the contents of the text, he produced an inadequate scholarly work. Ragep, on the other hand, understood the language and was an expert in the field. Thus, according to the recommendation of a specialist scholar, Saliba, his production was far superior to that of Dr Sulaiman.

The point is that scholars may produce inadequate scholarship because of their inability to access an adequate record, or they may fail to understand it. It seems safe to assume that earlier scholarship of the history of Islamic science was based on a handful of random studies of scientific manuscripts. Some of the studies were of high quality, but the absence of substantial evidence available to early scholars must have led them to describe the fate of Islamic science in an all-inclusive, and often reductive, manner.

Nevertheless, the question that may be raised is: in the absence of substantial evidence and/or proper understanding of original texts, what could have led scholars to offer sweeping generalisation about the fate of Islamic science? One possible factor is the pressure to publish. To illustrate, consider George Saliba's comments on this:

> Those who work in Islamic studies within the Western cultural domain are under pressure from their colleagues who have no access to Islamic languages to translate, annotate, and pre-digest primary texts of Islamic civilisation, in order to incorporate such texts into current critical discussions here in the West.[15]

These colleagues, explains Saliba, "want total pictures - not individually dissected texts – that by their very nature as historical texts tend to yield more than one reading and provide more interpretive choices."[16] The immediate problem of this approach is, "the lessons learned from one text may very quickly be generalised and hasty conclusions drawn without justification."[17]

This approach was clearly noticed in the scholarship under question. That is, a "total picture" about the fate of Islamic science was presented, regardless of what "individually dissected texts" would confer. Under pressure, overall conclusions were drawn about the fate of Islamic science regardless of contrary evidence, or at a time when the "elementary stock-taking of Islamic culture (such as determining the existence of manuscripts, cataloguing collections, correcting outdated

[15] George Saliba, "Writing the history of Arabic astronomy: problems and differing perspectives," *The Journal of the American Oriental Society*, 116, 4, Oct-Dec 1996, p.709(10).http://web6.infotrac.galegroup.com/itw/infomark/796/299/33216084w6/purl=rc1_EAIM_0_A19404331&dyn=3!xrn_9_0_A19404331?sw_aep=griffith.

[16] *Ibid.*

[17] *Ibid.*

catalogues, reading existing and well-catalogued manuscripts, etc.) is hardly even begun."[18] Such sweeping conclusions about the fate of Islamic science would not have resulted if there had been no pressure to produce knowledge from improperly studied material.

Perhaps, then, due to pressure, some scholars ended up subjecting the study of the fate of Islamic science to a sweeping general statement. As such, their conclusions should not be accepted without criticism, and their own interpretations should be double-checked against the facts.

C. Basing decisions on assumptions and not fact, conformity to given viewpoint contrary to evidence, or basing decisions on consensual approval

According to Hamilton, failure to check original sources means that scholars accept the following assumptions on face value: that original evidence actually exists; that the evidence is credible, without problem or difficulty; and that it has been accurately reproduced in all subsequent tellings.[19] A thoughtful review of some original sources would have forced a review, if not a rejection, of many single claims, not the least of which is the decline theory. It could be argued that many scholars, particularly the decline theorists, based their decisions on assumptions and not fact; conformity to given viewpoint contrary to evidence; or on consensual approval. Consequently, they gave no serious consideration to any alternative logic, even when relevant evidence suggested the need for it.

[18] *Ibid.*
[19] Hamilton, *op.cit.*, p.17.

Chapter Three has stated that an ideal work of scholarship tests the logical structure of a theory for internal consistencies, and test a theory's results for external consistency, with the observable facts of the real world. However, the review in Chapter Four showed that many claims were accepted as valid even though they lacked logic and empirical support. The suggestion, therefore, that scholars based their claims on assumptions, conformity, or consensual approval should not be ruled out. To illustrate: Toby Huff and Sayili were aware of new evidence and reported it in their work. They both showed that research in Islamic astronomy persisted beyond the eleventh century. However, they both clung to the handed-down claim of decline. In one way, they played down the importance of the new evidence by reaffirming that Islamic science declined.

D. Low level of research in the Arab world

Chapter Two has stated that no serious modern work of a general nature on Islamic science is available in Arabic, except Saliba's 1998 Arabic book, *The Origin and Development of Arabic Scientific Thought*. Saliba explains that most of the results of the last fifty years' research on Islamic science has not reached the Arab reader, let alone any serious discussion on the topic. In addition, whatever is being repeated in Arabic texts on this topic is old, usually erroneous, or subject to correction.[20] Hence, another possible reason for the inadequacy of adequate research is that scholarship in the Arab world has fallen to such a low level that Arabic people - clearly the best qualified to do this work – have simply

[20] George Saliba, *The Origin and Development of Arabic Scientific Thought* [Arabic] (Lebanon: Balamand University, 1998), p.15.

not been able to attempt it. Ultimately, this failure has affected the availability of scholarly work of original texts for the wider scholarly community.

Failure of Adequate Communication and Integration of Findings

Another basic, but fundamental, aspect of the failure of the scholarship under question is inadequate communication and integration of findings. In Chapter Three, it was stated that in an ideal scholarly community scholars are supposed to know what is worth communicating, how it can be communicated, what other members of the community are likely to know and believe to be true about certain subjects, and how other members can be persuaded. It was also said that experienced writers within a scholarly community are able to draw upon each other for knowledge about what will count as appropriate language, appropriate evidence, and appropriate reasoning. And it was said that appropriate communication, especially the written form, allows the preservation of results, theories and observations for the later reference by other scholars; and for providing opportunities for criticism, refutation and further refinement of the supposed facts. Members of scholarly communities understand how to communicate with each other using appropriate means and symbols (terms of analysis). Integration of information depends on communication. Integration of findings is vital because it helps "interpret, draw together, and bring new insight to bear on original research."[21] In short, the purpose of integration is interpretation and fitting results of research into a larger intellectual pattern. Certainly, the

[21] Charles E. Glassick, Mary Taylor Huber, and Gene I. Maeroff, *Scholarship Assessed: Evaluation of the Professoriate* (San Francisco: Jossey-Bass Publishers, 1997), p.9.

scholarship in question has failed to achieve the above aims of communication and integration.

To illustrate: one aspect of the failure of communication and integration is apparent in the inadequate use of mutually understood symbols (terms of analysis) to describe what happened to Islamic science. It was noticed in Chapter Four that some of the terms used by scholars appear to contradict each other (in the ordinary world things do not both freeze and decay, for example); overlap (standstill, frozen and ceased all mean the same thing); or were part of the same process (decline and decadence). Due to the failure to communicate adequately, the terms used proved to be a series of disparate, random and overlapping undertakings. This failure proved detrimental in the scholarship under question. For, as was explained in Chapter Three, the choice of symbols from among the available conceptual options predetermines the results, that is, how scholars will perceive, know, and understand "reality."

Another aspect of the failure of communication and integration is evident in the absence of awareness about Ibn Khaldun's theory. The failure to utilise Ibn Khaldun's theory cannot be entirely the result of inappropriate research. Since two scholars showed awareness of this theory, it seems reasonable to assume that the absence of adequate communication must have played a great part in allowing this theory to pass unnoticed for centuries. The scholarly community failed to communicate Ibn Khaldun's theory for the later reference by other scholars. Had it been communicated adequately, it could have stimulated opportunities for criticism and further refinements of many other single-faceted claims.

Failure in communication and integration can be illustrated using other examples. Take for instance Elena's fragmentation viewpoint. Though simplistic and single-faceted, Elena's re-interpretation is an important piece of work because it offers new perspectives regarding the fate of Islamic science. It is one of a few ideas that actually contravenes the long-held theory of decline, and rejects the 'stagnation' concept. However, not one single scholar showed awareness of Elena's re-interpretation. In fact, because his paper went unnoticed for years, Elena expressed surprise that I got hold of a copy of it myself. Consequently, it is safe to conclude that the failure to communicate and integrate evidence, theories and varying viewpoints in this long history must have led to a failure in adequate preparation; that is a failure to showing understanding of existing scholarship in the field.

The Absence of Mutual Criticism

Inadequate scholarship of research, and inadequate communication, leads to the uncritical acceptance of prior scholarly works. Chapter Three stated that acceptance that is not based on criticism could be either innocent (as with random error) or in some way "motivated," that is to say, the production of some predisposition.

The absence of criticism is clearly evident in the scholarship under question, particularly in the case of the decline theory, which has reigned for centuries. The persistence of the decline theory points to the presence of "uncritical critics."[22] With incredible persistence, generations of scholars have proved to be uncritically accepting of a decline theory unsupported by any empirical evidence. They have taken the theory of decline as real even when there were serious grounds for doubt and scepticism. The decline theory, at best, appears to be a social misconstruction generated over several decades, the product of several scholars. The others are a history of repetition, of uncritical communication of unfounded theories and claims.

The fact that this theory was uncritically accepted indicates that scholars had accepted it on assumptions, vouched for its validity, and passed it on to subsequent audience. The scholarly caution, the need for doubt, for scepticism, or for critical thinking, has been ignored in this centuries old theory. That is not to say that mutual criticism was entirely absent. There were instances of criticism, but they were problematic. For example, speaking about the cessation of Islamic science, Carra de Vaux asked: "whence came this torpor after a period of prolific activity?"[23] His answer was: "that this is a question, which raises very obscure problems of general psychology about which no one has yet put any definite theory and, as I have none to propound, I do not think I ought to attempt to discuss it."[24] Saunders criticised this conclusion on the basis that it is a "curiously defeatist attitude taken up a generation ago in the face of one of the most challenging problems of universal history."[25] Saunders criticised the fact that de Vaux was unable to offer explanations for this cessation, but he failed to criticise

[22] Hamilton, *op.cit*., p.27.
[23] Chapter four, section five.
[24] *Ibid.*
[25] *Ibid.*

de Vaux's initial assumption that Islamic science ceased. The absence of criticism of initial assumptions is repeatedly witnessed in the scholarship. This inadequacy must have facilitated the easy acceptance of baseless claims and theories, as in the case of the decline theory, because of their surface plausibility, there being no immediate grounds for doubt.

2. Why Did the decline theory Persist In the Absence of Empirical Support?

It has been demonstrated above that the scholarship under question has failed in the way it conducted adequate research, in communication and integration of findings, and in mutual criticism. That being the case, it is reasonable to ask: how is it that the decline theory persisted for centuries, and that the elements of that theory are still accepted and recounted by persons who should know better?

The review in Chapter Four has clearly shown that the decline theory is a scholarly error that proved to be remarkably persistent despite the availability of contrary evidence, and the attention of ever-growing numbers of concerned scholars. Based on substantial findings, scholars like Saliba and Sabra have rejected the basic claims of a general decline theory. But the elements of decline are still accepted and recounted by scholars who should know better, such as Huff, Hoodbhoy, Lindberg and McClellan III and Dorn. The decline thesis has had a long history. Many scholars have repeated it and agreed with it. But the agreement of many scholars should be taken as nothing more than a social construction. Agreement is not evidence. Without evidence of a decline this judgment is "every bit as fictive as the unsupported assertion of the tendency."[26] The repetitive and persistent acceptance of the decline theory provides evidence of what Hamilton calls "the power of a plausible paradigm."[27] That is, the convergence on the theory of decline is not a result of "compelling logic," or "pure reason,"[28] nor was it the result of individual assessment and judgment. It is a social misconstruction: a collective error, a widespread agreement about an interpretation of the fate of Islamic science that is mistaken and that is unsupported by evidence.

The trouble with the decline theory is that in the absence of a 'better one' it came to acquire the status of a paradigm, an analytical model that achieves currency even if it might not satisfy or fit all the facts. Accordingly, the decline theory was used to explain the fate of Islamic science in different areas, at different times, regardless of circumstances and evidence. In effect, the decline theory seems to have provided the ultimate solution for the fate of Islamic science.

However, the four case studies demonstrated that modern studies in the history of Islamic science show that productive, original scientific research persisted into the sixteenth century in the Islamic World. Thus, the theory of decline fails to explain the growing body of evidence, which confirms the rise, rather than decline, of science in the Islamic world after the eleventh century. It is surprising that such a fundamental, and obvious, feature of Islamic science should have remained obscure and escaped the attention of many decline scholars. The problem with the

[26] Arno Mayer quoted in Hamilton, *op. cit*. p.170.
[27] Hamilton, *op.cit.,* p.165.
[28] *Ibid.*

decline theory is not just that such a position is extreme, but that it also fails to accommodate the consequences of a feature of Islamic science mentioned earlier, namely, the presence of old, and appearance of new, evidence that proves the flourishing of Islamic science after the period of so-called decline. Given the presence of such evidence, the persistence of this theory unambiguously demonstrates that scholars "travelled great distance in the academic realm dispensing mock scholarship without encountering [until recently] any serious impediments."[29]

How did a mistaken decline theory, a social misconstruction, come to persist? One key aspect of the explanation for the origin of the decline theory must focus on the procedural factors discussed above: failure to research the claim, failure to communicate adequately, and failure of mutual criticism. Procedural factors are only one part of the problem. The persistence of this theory, its widespread acceptance based on no compelling logic or on any supporting empirical evidence, and the reoccurring of some of its elements in some contemporary scholarly work, force us to look beyond procedural factors.

3. Social Psychological Factors

The persistence of the decline theory can be related to a number of social psychological factors. These may include: the development of permissive standards for judgment (viewing Islamic science as inferior to Western science), and/or examining Islamic science as a background to talking about the West. The

[29] Hamilton, *op.cit.,* p.196.

following discussion of these factors will be based on speculations derived from logical reasoning, and on evidence derived from the previous chapters.

THE DEVELOPMENT OF PERMISSIVE STANDARDS FOR JUDGMENT: VIEWING ISLAMIC SCIENCE AS INFERIOR TO WESTERN SCIENCE

Chapter Three explained that Orientalism portrays Europe as an area of superior culture and the Orient, in comparison, as an area of patently inferior culture, waiting to be manipulated and controlled. With this attitude, Orientalist scholars served primarily to shape Europe's sense of identity rather than to explore or discover the Orient's. It was also explained that in the case of Islam, the Orientalist's notion defines the history of Islam with the "dominant theme of historical decay, retreat and decadence, because of which the explosive rise of Islamic society was followed by an equally rapid and total decline."[30]

In terms of science, then, Orientalism is a viewpoint of an historical ideology that views classical science as the achievements of European humanity alone.[31] In its "sociological version,"[32] this conception advocates the idea that Islamic science is dependent on Greek science, and that it acted as a mere sterile transmitter of Greek science to European civilisation.[33] The Orientalist's response to the claim that the Latin West was dependent on Islam for its scientific revival is that, "Islam

[30] Bryan S. Turner, *Orientalism, Postmodernism & Globalism* (New York: Routledge, 1994), p. 67.
[31] Roshdi Rashed (ed), *Encyclopaedia of the history of Arabic sciences* (London: Routledge, 1996), vol. 1p.xii.
[32] *Ibid*
[33] *Ibid*

was merely a medium between Hellenism and the Occident."[34] The result of this conception is that, "Islamic scholarship neither contributed to nor improved upon Greek heritage which eventually found its 'true' home in fifteenth - and sixteenth century European science and technology."[35]

Such a point of view, explains Nasr, "considers the present conception of science to be the only valid one; it therefore judges the sciences of other civilizations in the light of modern science and evaluates them primarily with respect to their "development" with the passage of time."[36] Even if one applies Western ideas of what science is, the fact is that in the Islamic Empire a great deal of high-quality science was done. Therefore, even if one commits the error described by Nasr, there is still a huge gap in the historical record, and in scholarship.

This notion dominated Orientalists' literature of eighteenth and nineteenth-centuries scholars, and was repeated in modern scholarship (as in the work of Huff). It seems likely that the Orientalist paradigm (or Orientalist prejudice) was a decisive factor for many scholars, and "guided" their interpretations throughout more than two centuries of the decline mythology. It can be argued that this mythology is the result of the nature of the knowledge that has informed the stereotypical treatment of the history of Islam.

Ernest Renan, for example, is one of those scholars who claimed that Islamic science declined. Chapters Two and Four highlighted that Renan is amongst those

[34] *Ibid.*,p.47.
[35] *Ibid.,* p.46. Also see George Saliba, *The Origin and Development of Arabic Scientific Thought*, *op.cit.,* p.164-168.
[36] Seyyed Hossein Nasr, *Science and Civilization in Islam* (New York: New American Library, 1968), Introduction.

who presented the culture of Islam as one whose greatest days had declined, and more importantly, could never be retrieved. In a commentary on Islam and science, contrary to evidence, Renan claimed, "the Mussulman [Muslims] has had the most profound disdain for instruction, for science, for everything that constitute the European spirit."[37] Bryan Turner explains that Renan believed that Islamic science could only flourish in association with heresy, and that Renan and other like-minded historians believed that "science in Islam was merely parasitic on Greek culture and that Islam was simply a vehicle transmitting Greek philosophy to the Renaissance in Europe."[38] Renan attacked the idea that the Islamic civilisation contributed to Western culture. He argued that Islamic civilisation was incompatible with scientific advance:

> All those who have been in the East, or in Africa, are struck by the way in which the mind of the believer is fatally limited by the species of iron circle that surrounds the head, rendering it absolutely closed to knowledge, incapable of either learning anything, or being open to any idea.[39]

The theme within the Orientalists' tradition by which Islamic science is seen as a transmitter of Greek science, and that it declined because of the inferiority of the Muslims to Europeans, became embodied in the work of other influential scholars like Max Weber. The famous sociologist Weber used arguments similar to Renan's. In common with Renan and other Orientalists, the theme of Weber's scholarship was "to provide an historical account of the emergence of what he

[37] Ernest Renan (ed.), "Islamism and science," *Poetry of the Celtic Race and Other Studies* (London: W.Scott., 1896), p.85 quoted in Bryan S. Turner, *Orientalism, Postmodernism & Globalism* (New York: Routledge, 1994), p.30.
[38] *Ibid.,* p.31.
[39] Renan quoted in Sardar, Z., *Orientalism* (Buckingham: Open University Press, 1999)

took to be the characteristics uniqueness of the West, namely the defining ingredients of rational capitalist production."[40]

The image that portrays Muslims as mere "torch-bearers" of Greek science, therefore, is a product of Orientalism, which "treats the Orient and Orientals as an 'object' of study inscribed by Otherness."[41] This typology is "based on a real specificity but detached from history, and thus conceived as intangible and essential,"[42] which, according to Sardar, makes the "European man, from Greek antiquity onwards, becomes the measure of all men everywhere."[43] Accordingly, the contributions of the Muslims to science "were deliberately ignored or suppressed."[44] So the view that Islamic science declined became orthodox and was repeated until recent times.

Examining Islamic Science As a Background to Talking about the West

The other problem with Orientalism is that it makes comparisons with the basic assumption of the inferiority of non-Western cultures. Saunders's decadence viewpoint is a good example of this. The trouble with Saunders is that he uses Islamic science as a background to talking about the West. Thus, he continually compares the Islamic civilisation to that of the West. Initially he equates the 'decline' of Islam with 'slipping behind' the West.[45] Later on, he asserts, "Clearly

[40] Turner, *op.cit.,* p.39.
[41] Abdel-Malek (1981) quoted in Ziauddin Sardar, *Orientalism* (Buckingham: Open University Press, 1999), p.59.
[42] *Ibid.*
[43] *Ibid.*
[44] *Ibid.*,p.60.
[45] Saunders, J. J., *Muslims and Mongols: Essays Medieval Asia* (University of Canterbury: Whitcoulls Ltd., 1977) p.101.

any attempt to explain why Islam and the West followed such different paths must start with a comparison of the conditions in which each was born and reached maturity."[46] Saunders proceeds to make this comparison – borrowing heavily from other Western scholars such as Gibb, Arberry and the decay theorist von Grunebaum. Saunders's comparisons conclude that Islamic science decayed because:

> Islam, from the first an essentially religious culture, turned back to its origins; the Hellenic element was gradually extruded; Aristotelian rationalism was repudiated by the Sufis as 'veiling the face of God', and profane science, which had always operated on the fringe and had never really cleared itself of the charges of impiety, was quietly abandoned as 'un-Islamic'. It has been said that 'Islam does not reach the stars', it has none of the insatiable curiosity of the Greeks.[47]

On the other hand, Christendom – claims Saunders – could have suffered the same fate as Islam had it not been for "its different backgrounds and different evolution."[48] Thus, to choose but one reason for that, Saunders explains, "the quarrels between Church and State (a distinction which had no meaning in Islam) promoted the elaboration of political theory and the growth of civil and intellectual liberty."[49] Consequently, Saunders concludes: "No such conditions existed for stirring up the stagnant life of Islam, which experienced no

[46] *Ibid.*, p.106.
[47] *Ibid.*, p.123.
[48] *Ibid.*, p.124.
[49] *Ibid.*

Renaissance. Islam had discovered God: it felt no need to discover Man and the World."[50]

Saunders argues that Islamic science decayed when compared to another civilisation *vis-a-vis* the Western civilisation. Using this idea, Islamic science could be progressing, could be producing new knowledge, and yet could be classed as being in decadence because it was doing so more slowly than the West. Comparison of Islamic science with that of Western science raises some immediate concerns: is this idea useful in determining the fate of Islamic science? Should Western science be the yardstick by which Islamic science is measured? And will the study of the fate of Islamic science with Western ideas of science result in making the former inferior and backward?

Saunders's comparative approach, of course, goes against his own suggestion that criteria for decadence must be suggested by the achievements of a given society, and not by achievements from other or later cultures (see Chapter Four). Furthermore, Saunders's comparative approach is not new, but is the repetition of previous Western scholars such as, but not limited to, Gustave von Grunebaum. This approach is problematic and has been heavily criticised by contemporary scholars[51] for a number of reasons.

[50] *Ibid.*
[51] See for example Bryan S. Turner, *Orientalism, Postmodernism & Globalism* (New York: Routledge, 1994); Sardar, Z., *Orientalism* (Buckingham: Open University Press, 1999); Z. Sardar, M. W. Davies, and A. Nandy, *Barbaric Others: A Manifesto on Western Racism* (London: Pluto Press, 1990); E. Said, *Orientalism.* (London: Routledge and Kegan Paul, 1978); E. Said, *The World, the Text and the Critic* (Harvard: Harvard University Press, 1983); and E. Said, *Representation of the Intellectual* (London: Vintage, 1994).

First, the study of Islamic civilisation with Western ideas of culture and civilisation "consistently found non-Western cultures and civilisations to be inferior and backward."[52] This approach examines the Islamic civilisation (and other non-Western cultures) "with a specific notion of cultural history, the origins and development of religions, the ways in which sacred texts should be understood and interpreted, political ideas and how human societies evolve and develop."[53] Accordingly, this approach found Islamic science "to be not science and perpetuated the fiction that true science was created by and belong to the West."[54] That is why, for example, Saunders claims "the only science which came to be studied in Islam for its own sake was that of medicine,"[55] implying that the achievements in other scientific fields was not really science.

Second, this comparative approach treats Islamic science "as an 'object' of study inscribed by Otherness."[56] This object is considered "passive, non-participant and 'endowed with an "historical" subjectivity that is above all non-active, non-autonomous, with no sovereignty over itself."[57] Furthermore, this view sees Islamic science in "essentialist terms," which translates into "a characteristic ethnist typology."[58] This typology is "based on a real specificity but detached from history, and thus conceived as intangible and essential." Accordingly, Western science becomes the measure of all science everywhere.

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52 Sardar, *Orientalism*, *op.cit.,* p.4.
53 *Ibid.*
54 *Ibid.*
55 Saunders, *op.cit*., p.109.
56 Abdel-Malek in Sardar, *Orientalism*, *op.cit.,* p.59.
57 *Ibid.*
58 *Ibid.*

Consequently, this comparative approach has its own methodological difficulties. It is therefore reasonable to assume that it may have been an instrumental factor in influencing some scholars' judgment regarding the fate of Islamic science.

SUMMARY AND CONCLUSION

The aim of this chapter has been to offer some explanations for the inadequacy of scholarship under question to explain what happened to Islamic science between the eleventh and sixteenth-centuries. It found that a range of factors, working individually or collectively, might have been instrumental for these failures. Certainly, most of the inadequacies were as a result of procedural factors, most important of which was the absence of adequate scholarship of research, inadequate communication and the absence of mutual criticism. Another keen observer may well find other causes. In the context of these inadequacies an important question was posed: why some theories, like the decline theory, persisted for centuries? It was postulated that procedural factors were one aspect of the problem, but social psychological factors were also considered. Thus, it was hypothesised that the development of permissive standards of judgment, and examining Islamic science as a background to talking about the West, must have affected some scholars' perceptions of the fate of Islamic science.

In order to avoid simplistic and erroneous descriptions of the fate of Islamic science, it seems necessary that one must begin with an adequate intellectual model. The following chapter attempts to postulate such a model.

10

THE FATE OF ISLAMIC SCIENCE: A POSSIBLE ADEQUATE INTELLECTUAL MODEL

INTRODUCTION

Thus far, the thesis has made two key points. First: scholarship has essentially failed in understanding what happened to Islamic science. Sophisticated early work, as that of Ibn Khaldun, was neglected in favour of simplistic statements. After Ibn Khaldun there was a centuries-long gap, in which even excellent historian used simple, dismissive terms and concepts regarding what happened. Second: examination of the evidence for specific areas of science shows that different fates awaited Islamic science, in different areas, at different times. Certainly, simple ideas about decline were clearly falsified by research showing that Islamic science made great strides centuries after it was thought to have been in decline. A detailed discussion for these inadequacies was presented in Chapter Eight.

Since no clear account is given of what happened to Islamic science, it is impossible to discuss the reasons for its fate. Therefore, a comprehensive approach to the study of the fate of Islamic science is clearly needed, one that examines both the cultural environment, and the interaction among different cultural dynamics at work. However, since so many original documents on Islamic science have not yet been examined, it is not possible to state with confidence what the final model will look like. But, on the basis of what is known, some tentative generalisations can be made.

This chapter is organised in the following manner. Section one gives an overall intellectual sketch. Section two describes a possible comprehensive approach to the fate of Islamic science. The last section gives some concluding remarks.

1. An Overall Intellectual Sketch

After the death of Prophet Muhammad in AD 632, the Islamic empire expanded far and wide. It conquered Syria, Iraq, and Jerusalem by 637, Egypt by 642, Central Asia and western North Africa by 670. Less than fifty years later the Islamic empire conquered Spain, Persia, and India and was conducting raids across the Pyrenees.[1] The Islamic empire evolved through some twelve centuries, rarely achieving political unity or balance for long periods. From about 661, the Islamic empire went through nearly twelve centuries of dynastic and political manoeuvring and strife, including periodic wars with Christian crusaders and invading Mongols.[2] The political empire was split into many caliphates, each one the equivalent of a principality. These independent domains eventually shrank, were absorbed, or disappeared.[3]

Over time, some thirty dynasties emerged, flourished, declined, and expired. Between the seventh and thirteenth centuries arose the great medieval Arab

[1] H. R. Turner, *Science in Medieval Islam: An illustrated introduction* (Austin: University of Texas Press, 1995), p.5.
[2] *Ibid.*
[3] *Ibid.*, p.6.

dynasties: the Umayyads, with their capital at Damascus; the Abbasids, centred at Baghdad; the separate Umayyad dynasty that flourished in Spain; and the Fatimid dynasty of Egypt and northwest Africa.[4] Together these regimes brought about the first great flourishing of Islamic civilisation. Between the eleventh and thirteenth centuries, this young civilisation faced the great challenges of Christian crusaders, migrating Turks from the Eurasian steppes, and the invading Mongols from Central Asia.[5] These incursions by other, different societies with unique cultures of their own profoundly affected the character and evolution of Islamic society and particularly of the later Muslim dynasties that flourished after the thirteenth century, most notably the Mamluks in Egypt, the Ottomans in Turkey, the Safavids in Persia, and the Mughals in India.[6]

By the sixteenth century, the Islamic empire covered a large part of the world, from West Africa through the Mediterranean, across Central Asia into India, and even across the ocean into Southeast Asia. The foundation of this empire stretched more than nine thousand kilometres between the Atlantic and the Indian Ocean. Such was the broad geographical and historical stage on which the scientists of the Islamic world produced their work. Hence, to understand what happened to Islamic science, one should first consider the cultural environment, and the interaction among different cultural dynamics at work.

[4] *Ibid.*, p.7.
[5] *Ibid.*
[6] *Ibid.*

2. A POSSIBLE COMPREHENSIVE APPROACH TO THE FATE OF ISLAMIC SCIENCE

In the light of the abovementioned, it can be well realised that although Islamic science is in an important sense a single tradition, it consists of a series of events whose circumstances differ widely, and therefore demand to be analysed individually. Therefore, it is important to have a good number of basic specialised monographs before general conclusions are made about the fate of Islamic science. This approach has its methodological difficulties: such an undertaking requires an examination of a wide number of scientific activities, in a vast geographical area, under different contextual conditions, and over a huge period of time. The advantage of this approach is that it prevents scholarship from covering all areas of Islamic science in an all-inclusive and reductive manner. Certainly, the benefits of this approach was noticed in the work of scholars as al-Hassan and Saliba, which has led to a rejection of some long held theories. More specialised monographs are needed before venturing into general descriptions of the fate of Islamic science.

Another recommendation for achieving an adequate model, and following from the previous one, is to realise that Islamic science is a major topic for study in its own right. It must not be considered as a minor subsidiary to the rise of Western science. It needs its own body of scholarship, and to some degree its findings will be distinct from those of other areas such as the history of Western science.

In addition, the unique features of Islamic science must be taken into account. In the West there is much argument about the role that Christianity played in the rise of science. In the Islamic world it is perfectly simple: without Islam there would have been no Islamic science, and probably very little science of any kind in the area under study. Later, there were different interpretations of Islam, but its role in the rise of science is quite clear.

The other feature is that Islam spread over an enormous area, and much of it was at the junction between several other important cultural areas (China, India, North Africa, Europe). This was both an opportunity and a problem. It was an opportunity to use knowledge from many cultures, and this the Muslims took brilliantly. It was also a problem, in that aggression and destruction could come from any quarter. And indeed, it came from Europe and from the Mongols, with terrible results.

A third recommendation is that criteria must be established to help describe best what happened to Islamic science. For example, these criteria may include the suggestion presented by Sabra to compare the level of production in the eleventh and fifteenth centuries. Or Saunders's suggestion that decadence could be said to have occurred if the stream of creative thinking evaporated, the pursuit of knowledge for its own sake was severely discouraged, and the most promising lines of inquiry were never followed up. But the criteria must be suggested by the achievements of Islamic science itself, and not by achievements from other or later civilisations (as Saunders and others have done). Once such criteria are established one can look for causes suggested by them. This is a tall order, but a valid one. Once that is considered, it will become easy to realise that the reasons for the different fates, at different times, vary. Some possible reasons, which may be considered, are as follows.

First, there are external imposed factors such as the sack of Baghdad by the Mongols, and the attacks of the crusaders on different regions of the Islamic empire. In 1256, the destruction of Baghdad by the Mongols ended science there for a while, at least. The cities which were the repositories of knowledge and which had libraries studded with priceless books were razed to the ground; scholars were put to death; men and women, young and old were killed.[7] According to historians like al-Maqrizi (1364-1442), and the famous ‘Ata Malik Juwaini[8] (d.1283), the damage caused upon Baghdad was catastrophic.[9] They estimated that hundreds of thousands of men, women, and children were killed. Amongst these were thousands of eminent scholars, scientists, writers and poets. Consequently, what Juwaini had called “the famine of science,” plagued Baghdad and stretched from Transoxania to the shores of the Mediterranean.[10] Clearly, after the fall of Baghdad, it would be understandable for many rulers to concentrate upon survival rather than long-term scholarship.

The devastation caused by the Crusades was not as horrendous as that of the Mongols, especially as far as the fate of science and intellectual life was concerned. The Crusades (in particular the First Crusade) resulted in the killing of

[7] C. A. Qadir, *Philosophy and science in the Islamic world* (London: Croom Helm Ltd, 1988), p.122.
[8] He was one of those Iranian officers who belonged to a distinguished family of ministers and administrators and was used by the Mongols for civil services.
[9] M.S. Bhatti, *Political and Cultural history of Islam* (Lahore: Dogarsons, 1996), pp. 480-481
[10] *Ibid*., p.484.

scholars residing in invaded areas. Those who were not killed escaped to larger Muslim cities, which caused a type of a "brain drain" from invaded areas such as Jerusalem. The conquest by the army of the First Crusade of such towns as Jerusalem created a generation of wandering scholars, learned and cultured Muslims who sought patronage in the larger Muslim cities of the hinterland.[11] For example, in the early twelfth century, Ibn al-Qaysrani escaped Jerusalem only to continue his studies in Damascus, where he was instructed in religious traditions, poetry, belles-lettres, astronomy, engineering and mathematics. His study of the last two subjects equipped him to pursue a career as a horologist and he seems to have been in charge of the maintenance of clocks in various Palestinian and Syrian towns.[12]

A second possible cause is that, as one area of the Islamic world became unfriendly to science (whether by conquest or internal politics) it is possible that scholars migrated to other areas, setting up new centres. For example, it is now known that the Mamluk rulers in Egypt managed to hold off the Mongol invasions.[13] Consequently, after the destruction of Baghdad, the second Mamluk's Sultan Baybars invited Baghdad's ruling family to resume their office in Cairo. With this move many Islamic scholars of the east immigrated to Egypt (and in some cases to Syria) fleeing from the Mongol yoke. This flux of Islamic scholars to Egypt was paralleled by another flux, but from the west.[14] The Spaniards

[11] R., Irwin, "Muslim response to the Crusade," *History Today*, 47, 4, April 1997, p.43 (7).
[12] *Ibid.*
[13] John Masson Smith Jr., "Mongols and Mamluks: The Mamluk-Ilkhanid War, 1260-1281," (book reviews), *The Journal of the American Oriental Society*, 118, 1, Jan-March 1998, p54(9).
[14] `Inan M., A., (1958), *Tarikh al-Jami' al-Azhar*; Qura'a, S., (1968), *Tarikh al-Azhar fir Alf `Am*; and Al-Shinnawi, A., A., *al-Azhar Jami'an wa Jami'atan*. (1983) www.ims.uwindsor.ca/~azhar/HISTORY/history.html.

overran many Spanish Islamic emirates between 1236 and 1261; consequently the famous Islamic schools in Cordoba, Cartagena, Seville and Valencia were destroyed. Since Mamluk Egypt was the most powerful state in the Muslim world at the time, it became the pole of attraction for western flux of scholars. Undoubtedly, this is but one reason for the flourishing of scientific activity (especially medicine and astronomy) in Egypt, when it was destroyed elsewhere.[15]

A third possible cause is that since the Islamic empire was not internally united, possibly the rulers of different parts had different priorities at different times. Sometimes these favoured science, sometimes not. Sometime, they favoured one branch of science over another. For example, it is now known that in the early period of Islamic hegemony the royal patronage of the Abbasid, Samanid, or Fatimid court offered generous support to science.[16] But during the later centuries, this patronage was given to practitioners of the occult.[17] Patronage of the philosophical and exact sciences was not an outstanding feature in the courtly culture of the Burji or Bahri sultans, and men pursuing the scientific tradition were then forced to make a living as best they could.[18] Thus, casting horoscopes was an attractive option because of royal patronage and the "general public offering a market of buyers ready to pay for and believe almost anything that was well dressed in logical structure and scientific jargon."[19] This offered the hope of

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[15] *Ibid*

[16] J. W., Livingstone, "Science and the Occult in the thinking of Ibn Qayyim Al-Jawziyya," *The Journal of the American Oriental Society*, 112, 4, 1992, p.598 (13).

[17] *Ibid.*

[18] *Ibid.*

[19] *Ibid.*

gain or security in a tumultuous period, and accordingly the occult sciences prospered.[20]

Finally, it is known that overall, Islam supports all aspects of learning. However, there is no doubt that state and religious authorities, at particular times, had reasons for interpreting Islam in ways that suited their particular priorities. This may have encouraged the flourishing of a certain branch of science at the cost of another. For example, and following from the example of the occult given above, it is now known that the Hanbali theologian Ibn Qayyim al-Jawziyya (1292-1349) was one of the most prolific defenders of traditional religious teachings in the Arabic-speaking lands of Islam.[21] Due to the popularity of the occult sciences which he perceived to be undermining the orthodox traditions of Islam, he attempted to disprove these pseudo-sciences, particularly alchemy, astrology, and augury.[22] The weightiest part of his attack was directed against astrology, which he refutes on three levels: on the historical, by examples of important Islamic dynasts whose court astrologers advised them to act in accordance with a horoscope that in the event turned out to be wrong; on the technological, by arguments of earlier authoritative scientists that the tools of observation and tables of planetary positions failed to meet the exactitude required by a possible science of astrology; and on the scientific, revealing the arbitrary conventions and contradictions of the principles underlying astrology.[23]

[20] *Ibid.*
[21] *Ibid.*
[22] *Ibid.*
[23] *Ibid.*

A fourth recommendation, and one that deals with basic scholarly practice, is that scholars need to start by doubt or scepticism about long held theories, and to assume that the opposite could be true.[24] This Cartesian principle was missing in most scholarship regarding the fate of Islamic science; hence most scholars accepted the "groupthink theory"[25] of decline or other ideas that have similar implications. A remedy for the groupthink problem is to give more systematic attention to alternative theories. This is something that should be done by individual researchers themselves. They should think and review the "fundamentals" of major theories – those from the past, those with contemporary currency, and also any significant new arrivals on the scene.[26] Researchers should examine all social theories regarding the fate of Islamic science. Failure to do so produces single all-purpose explanatory accounts of what happened. Such accounts prevent insights from other perspectives being discovered.

A fifth recommendation is the need for "greater effective theoretical pluralism."[27] That is, researchers should be aware of the different theories and views available, work with those theories and views, think easily in those terms, and be able to apply them to any research material at hand.[28] Accordingly, it is recommended that researchers seeking to find answers to the general problem of the fate of Islamic science should begin by understanding the fundamentals of Ibn Khaldun's theory. They should also understand the fundamentals of the decline theory, and the more recent views and recommendations suggested by al-Hassan, Sabra and

[24] Richard, F. Hamilton, *The social Misconstruction of reality: Validity and Verification in the Scholarly Community* (New Haven: Yale University Press, c1996), p.217.
[25] *Ibid.*
[26] *Ibid.*
[27] *Ibid.*, p.218
[28] *Ibid.*

Saliba. This requires that attention be given to perspectives that have been, for one reason or another, neglected and/or rejected, such as Elena's fragmentation viewpoint. Elena rejected the decline and stagnation theories and offered a reinterpretation characterised as fragmentation. Although not popular, and going against the conventional wisdom, the fragmentation suggestion deserves attention, rather than the complete neglect that it met.

A sixth recommendation is that scholars need to be aware of their shortcomings when researching cross-cultural studies. In the case of the history of Islamic science knowledge of Arabic is not sufficient, for instance. Dr Sulaiman's expertise in Arabic did not help him when he attempted to translate al-Tusi's specialised work. Understanding of a particular language should be, therefore, coupled with subject expertise. In addition, scholars with different expertise should bring their expertise to bear on the contributions of another. That is, before scholars arrive at conclusions about the fate of Islamic science, the expertise of specialists should be called upon.

Finally, theories regarding the fate of Islamic science must be reviewed in the light of reliable evidence, both old and new. Serious scholarship cannot accept, nor repeat, theories that are not based on evidence. Recent evidence in the history of Islamic science contravenes the conventional understanding of what happened to Islamic science. It shows that in at least a number of branches Islamic science flourished beyond the so-called decline period.

CONCLUSION

The aim of this chapter was to provide a possible intellectual model for the fate of Islamic science. Despite their large quantities, theories on the fate of Islamic science are all too often inclusive, and often reductive. While many scholars offered conceptual descriptions of what happened, the cumulative legacy of the Islamic science is simply overlooked. Consequently, Islamic science is seen as one that has suffered a uniform fate. Certainly, the inadequacies of this approach calls for a more comprehensive one. Such an undertaking calls for an examination of wide-ranging scientific activities, in a vast geographical area, under different contextual surroundings, and covering many centuries. Such an approach would require overcoming real hurdles in the way of institutional resources, collections of manuscripts and the like. Although the task is daunting and a great deal is unclear, such a model as suggested above, and such a community of scholars, is beginning to emerge.

11

CONCLUDING REMARKS

The aim of the thesis has been to comprehensively survey and evaluate scholarship on the fate of Islamic science between the eleventh and sixteenth-centuries, and to outline a more adequate scholarly approach. The thesis also attempted to assess the logic and empirical accuracy of the accepted decline theory and other alternative views regarding the fate of science in Islam, and investigates the procedural and social physiological factors that give rise to inadequacies in the scholarship under question. It also attempted to construct an intellectual model for the fate of Islamic science, one that examines the cultural environment, and the interactions among different cultural dynamics at work. Drawing upon Ibn Khaldun's theory and recent substantial evidence from the history of Islamic science, this thesis also entailed justifying the claim that, contrary to common assumptions, different fates awaited Islamic science, in different areas, and at different times.

The conception of scholarship that was adopted in this thesis is widely recognised, and yields some fairly straightforward criteria, which makes it possible to examine whether a functioning scholarly community exists that could investigate what happened to Islamic science. The key point is that the approach used here was a normative one: what should be the case rather than what actually is. What factors would facilitate (or hinder) the production of valid knowledge in a scholarly community? The main practical aim was to apply the normative account of a true scholarly community to four case studies from the history of Islamic science in order to throw further light on practical problems in the scholarship under question.

The study has demonstrated that, while there is widespread agreement that Islamic science declined after the eleventh century, there is no consensus on precisely what happened. The study also showed that, for the first time, there are many views on this issue, and that they can be roughly categorised into four groups:

1. Ibn Khaldun’s multi-dimensional theory that claims that different fates awaited Islamic science, in different areas and at different times.
2. The influential and persistent decline theory that claims Islamic science went through a golden age in the eleventh century, and then entered a period of more or less uniform decline. The decline theorists would accept the existence of some science after the eleventh century, but would postulate that it was always inferior in both quantity and quality to what had gone before.
3. Non-decline ideas that suggest that Islamic science “decayed,” “froze,” “stagnated,” and that it came to a “standstill.”
4. Finally, the more recent view that rejects the notion of a general decline and states that Islamic science flourished up to the sixteenth century.

For the first time, the claims of an array of scholars – old and new – were documented and analysed here. Based upon insights drawn from the theoretical and practical parts of the study, the thesis demonstrated two key findings: first, scholarship has essentially failed in understanding *what* happened to Islamic science. After Ibn Khaldun, there was a centuries-long gap in which even excellent historians used simple, dismissive terms regarding what happened. Second, examination of the evidence for specific areas of Islamic science shows that different fates awaited Islamic science in different areas, and at different times. Certainly, this study has demonstrated that there is *no* evidence of a general decline (or any single-faceted fate), and it is clear that some branches of Islamic science flourished for centuries after the eleventh century.

The study has also demonstrated that, while few views were closer to reality, most views involve social misconstructions that have been widely accepted; and they have persisted for centuries. This point is crucial for our understanding of the impact of Islamic science in a variety of situations. Islamic science itself is important, but *what* actually happened to it, *where* and *under what conditions*, are also critical in determining the impacts it had on the grand narrative of the history of science.

The main aim of this concluding chapter is to consider the implications of the study's findings in terms of these issues, to outline its limitations, and to suggest some directions for future research. The chapter is organised in the following manner. Section one gives a summary of findings. Section two describes the implications of the study. The last section explains the limitations of the study and gives directions for future research.

1. SUMMARY OF FINDINGS

Chapter Two began by demonstrating that a huge and brilliant entity, the Islamic Empire, did a great deal of science. The chapter also highlighted some of the ways in which classical and contemporary scholars have understood the importance of Islamic science in the grand narrative of the history of science, and how this understanding has progressed in recent years. It was concluded that Islamic science itself *is* important, but *what* eventually happened to it is also critical. Since our aim is to examine the adequacy of the scholarly community in determining what happened, it was important to ask what kind of scholarly community would be best equipped to investigate the question? Chapter three, therefore, examined the nature of an ideal scholarly community, and the qualitative standards that it needs for, and the constricting problems that may hinder, the production of reliable knowledge. This provided a number of useful conceptual tools. With that in hand, an attempt was made to construct a framework of an ideal scholarly community, which included an account of qualitative standards, qualities of a scholar and constricting problems. It was said that a scholarly community is a discourse community that is symbolically bonded by means of qualitative standards, the absence of which renders scholarly production defective. Scholarship was then categorised into six separate, but overlapping functions. Chapter Three explained why these functions are vital to a scholarly community, and also explained that they need to be evaluated by a set of qualitative standards that capture and acknowledge what they share as scholarly acts.

It was argued that works of scholarship involve a common set of qualitative standards: clear goals, adequate preparation, appropriate methods, significant results, effective presentation and reflective critique. These were articulated and it was stated that, collectively, these standards offer a powerful conceptual framework to guide evaluation of scholarship. The qualities of a scholar were then explained, including: courage, persistence, consideration, humility and integrity. Integrity was a vital quality that also encompasses objectivity, honesty and fairness. Objectivity does not permit the scholar to hide some facts, nor to consider race, religion, or political party in a scholarly work. It was also argued that these qualities are important because they shape scholars' intellectual work and knowledge. The problems that may hinder the production of reliable knowledge were then outlined, including procedural and social psychological problems.

For the period of Ibn Khaldun (1332-1406) to the present, Chapter Four presented an extensive critical review of both classical and contemporary scholarship, exclusively or partially, devoted to the question of the fate of Islamic science between the eleventh and sixteenth-centuries. The aim has been to elucidate one key point: the adequacy (or inadequacy) of the scholarly community to explain what happened to Islamic science between the eleventh and sixteenth-centuries. The analyses revealed that one of the most important problems in the corpus of scholarship is that it has failed to understand what happened to Islamic science, and that after Ibn Khaldun, there was a centuries-long gap in scholarship, in which even excellent historians used simple, dismissive terms to describe what happened. It was also found that the fate of Islamic science after the eleventh century is represented in strongly negative and single-faceted terms: "declined," "froze," "stagnated," or that Islamic science "decayed." These terms were simplistic and often overlapping. Furthermore, it was found that, with the exception of the work of a small number of scholars (Sayili and Saunders), the rest of the scholarship offers little, if anything, about what processes these terms actually involve, and nothing about what they actually mean. It is evidently taken for granted that these terms are clear and need no further elaboration.

Chapter Four also demonstrated that there are very few noteworthy cases where Islamic science is being represented in ways that do not imply negativity. Ibn Khaldun's six centuries old theory represents the fate of Islamic science in a positive and multi-faceted way. There are also some few narratives that present more complex descriptions; however, even Ibn Khaldun's complex theory, which is arguably the most adequate in the scholarship, is non-comprehensive. Some modern scholars, like Saliba, presented a challenge to the common argument that Islamic science declined. However, in the absence of any significant challenges to the common claims of the fate of Islamic science, particularly that of decline, it became evident that, at the very least, the scholarship seems to offer support to the work of discourses that construct the fate of Islamic science in single-faceted, simplistic and reductive terms.

In order to examine the validity of the different scholarly claims, four branches of Islamic science, belonging to different areas, were examined. Based on the most recent research, Chapters Five, Six, Seven and Eight examined the fate of mathematics, astronomy, and medicine in different geographical areas. The aim was to see how far the fate of these branches of Islamic science fit with the theoretical claims established in Chapter Four.

Examination of the fate of mathematics in the Maghreb illustrated that, contrary to a general decline theory, or other single-faceted fates (such as froze, stagnated, and decayed), there was a rise in mathematical activities after the eleventh century. Examination of the fate of astronomy in Persia between the eleventh and sixteenth centuries illustrated that there was an intense astronomical activity. In the Maragha observatory in Persia, original contributions in astronomy (not withstanding contributions in other scientific fields like mathematics) were made. The originality and importance of these contributions can be estimated by the impact they had upon later European astronomical research, which may perhaps have laid the foundation for Copernican astronomy itself. Finally, modern research in the history of medicine and astronomy in Syria and Egypt showed that the learned medical and astronomical communities remained quite active, and made original contributions, through the thirteenth and fourteenth century.

Taken together, examination of these case studies revealed that all single-faceted theories and views fail to explain the growing body of evidence, which confirms the rise of some branches science in the Islamic world after the eleventh century. It also demonstrates that Ibn Khaldun's theory is more complex and is closer to reality than all others. With this understanding, Chapter Eight ventured into discussing the possible reasons for the inadequacies of scholarship to understand and explain the fate of Islamic science.

Chapter Eight postulated that a range of factors, working individually or collectively, might have been instrumental for these inadequacies. Certainly, most of the inadequacies were as a result of procedural factors, most important of which was the absence of adequate scholarship of research, inadequate communication, and the absence of mutual criticism. In the context of these inadequacies, a serious question was raised: why some theories, like the decline theory, persisted for centuries? It was argued that procedural factors were one aspect of the problem, but social psychological factors were also examined. Consequently, Chapter Eight proposed that the development of permissive standards of judgment, and examining Islamic science as a background to talking about the West must have affected some scholars' perceptions of the fate of Islamic science.

It is clear from this summary of findings that the scholarship as a whole failed to understand, and thus describe, what happened to Islamic science. As detailed in the analyses, most of the claims in the narratives unequivocally encourage single-faceted and simplistic understandings of what happened.

2. Implications

In this study, a corpus of scholarship containing the work of many eminent scholars has shown the continued acceptance of a range of discursively constructed 'truths' about the fate of Islamic science. Amongst other aims, this work entailed justifying the claim that, contrary to common assumptions, different fates awaited Islamic science in different areas at different times. The evidence documented in this study reveals that these texts to be actively engaged in representing the fate of Islamic science in single-faceted and negative terms, thus undermining its originality, and the effect it had on the grand narrative of the history of science.

The study's findings therefore have significant implications not only in the field of Islamic science's literature, but also in historiography and in education, particularly in the history of science, where fictional narratives of the kind examined in this study are used as resources to support teaching and learning activities that are expected to be consistent with scholarly principles. In the field of historiography, the study reaffirms "the rejection of the idea that they [historians] can produce an objective description, uncontaminated by their own attitudes and values, of what actually happened."[1]

Within the field of education, the study's findings should be of considerable interest to academics and teachers, especially those involved in the field of the history of science. It is clear that the ideologies that are nurtured by the representation of the fate of Islamic science in the research corpus influence understandings of the history of Islamic science and civilisation; thus they are potentially negative in their effects. Our findings can open up new ways of thinking about the entire corpus of literature on the history of Islamic science and civilisation, as well as new perspectives from which to consider the educational

[1] A. Bullock, and O. Stallybrass, *The Fontana Dictionary of Modern Thought* (London: Fontana Books 1977), p.286.

value of that literature and how it can best be used to enhance our understanding of Islam's contribution to modern science and civilisation.

The findings are also relevant to the broad concerns of researchers and practitioners in a variety of other fields. For example, regardless of their particular fields of interest, researchers and practitioners are likely to welcome the way this study sheds further light on the nature and workings of the scholarship that oppose the contributions of Islamic science and undermine its successes and influence. Indeed, the study has highlighted both the persuasive power and the extraordinary durability of unsubstantiated claims, and the extent to which, unless they are actively, explicitly and consistently challenged, they can shape the outcomes of historical studies in ways that can seriously alter 'reality.'

Not surprisingly, some of the more significant implications to be drawn from the findings are relevant to literature on the history of Islamic science. The study has added a new perspective to research findings on the nature of such literature, by drawing on analyses of the discursive misconstruction of the fate of Islamic science. This approach has illustrated that there is a common element linking literature on the history of Islamic science, one that represents it with the idea of 'failure' after the eleventh century represented in most cases as that of decline.

However, as this study has demonstrated, the apparent decline is no more than a social misconstruction of reality. At the same time, the literature reviewed in Chapter Four has made it clear that other single-faceted discourses are no more accurate than the decline theory. In this case, the illusion that Islamic science froze, decayed, or came to a standstill, to name just a few, serves to divert attention from evidence that Islamic science flourished after the eleventh century. By analysing the research corpus from the perspectives made available by both sets of research literature, the study has demonstrated the subtle yet powerfully effective ways in which these two sets of discourses work together to mask the importance and influence of Islamic science in the grand narrative of the history of science.

The conclusions that the texts in the research corpus portray are primarily those of ‘failure,’ rather than ‘progress’ and ‘success.’ Other studies have already provided clear evidence that Islamic science flourished after the eleventh century; however, little explicit research attention has previously been given to the relevance of narrative representations of the fate of Islamic science to that discursive work. Thus, part of the contribution of this study is in revealing that, despite the relatively minor role such representations appear to play, adequate representation of the fate of Islamic science is crucial to our understanding of what actually happened and why. It seems that the purported failure-centeredness of literature on the fate of Islamic science renders that literature a particularly useful vehicle for backlash discourses that seeks to construct the fate of Islamic science in none-failure terms.

It follows that researchers in the field of the history of Islamic science, especially those concerned about what happened and why, cannot allow the illusion of failure-centeredness to blind them to the significance of narrative representation of the fate of Islamic science. It seems that researchers would be rewarded by giving closer and more systematic attention to the representation of what happened to Islamic science in relevant literature, however trivial to the failure-centred narratives those representations might initially seem to be.

Also in the field of the history of Islamic science, the findings of the study offer substantial grounds for a reconsideration of the causal factors postulated to explain the fate of Islamic science, such that they are more explicitly oriented towards multi-faceted suggestions. For example, suggestions that Islamic science declined because of religious factors, or because of the absence of a capitalistic economy in Islam, needs to be reviewed in the light of the findings in this study. The point is that, if Islamic science did not decline between the eleventh and sixteenth centuries (a decline has not been demonstrated), then such casual factors become automatically invalid.

To conclude this discussion, it is important to note that the methodological approach adopted for this study, and the research practices used to tackle the analytical tasks it entailed, could usefully be adapted for the purposes of examining textual representations of a variety of historical concepts. The following, then, discusses the limitations of this study and the possibilities for further research.

3. Limitations of The Study and Directions for Further Research

While the research in this study has been comprehensive, it has been limited by its focus on texts that are written in English, Arabic and sometimes translations of texts written in other languages like Spanish. While it is arguable that these texts are representatives of the literature on the history of Islamic science, it cannot be claimed that they are representative of the full range of literature produced on this topic worldwide.

It was not feasible to do full justice to the analytical possibilities of the corpus of scholarship examined here. As explained in Chapter Four, it was in recognition of this that the analyses focused on scholarship's description of 'what' happened to Islamic science and not 'why.' Hence, re-examination of causal factors for the fate of Islamic science in the light of our study might constitute the basis of further research. Also, it must be said that some of the resulting analyses were more exhaustive than others: there is undoubtedly more that could be said about the ways in which the fate of Islamic science is represented in the many texts analysed in Chapter Four, and the possible reasons for the failure of scholarship analysed in Chapter Eight.

In particular, dimensions of 'Orientalism' in the representation of Islamic science have been insufficiently addressed in this study. While it was demonstrated in Chapter Four that common sense understanding about Islamic science represent its fate to be one of decline and failure, the analyses did not attend to the influence of Orientalism in the representation of the fate of Islamic science in the research corpus in an exhaustive manner. This clearly limits the value of our findings. Notwithstanding the fact that much work has been done on Orientalism and the Islamic civilisation, it should be noted that no specific research has been conducted on Orientalism and the fate of Islamic science. Certainly, it is possible to recognise here concerns that might constitute the basis of further research.

A range of other aspects relating to the causes of the failure of the scholarship to understand and represent the fate of Islamic science analysed in Chapter Eight also warrant greater attention than they received in this study. For example, the study suggested a number of hypothetical factors backed up by our understanding of the nature of the scholarly community described in Chapter Three for this failure. These factors included concern with the "inner logic" of a claim, and not the realism of initial assumptions; basing decisions on faith and not fact, conformity to given viewpoint contrary to evidence, or basing decisions on consensual approval. It was not feasible, however, for the study to explore these issues to any great extent, and this clearly limits the value of their suggestions. Further research might shed some more light on these issues.

It was also not feasible to examine the fate of all the branches of Islamic science in different regions and times. It was in recognition of this that our study limited it self to four, but significant, branches. It was highlighted, in Chapters Four and Eight, that more specialised monographs are required before generalised conclusions can be made, but it is worth re-stating this here: undoubtedly examination of other branches of Islamic science could usefully shed light on the fate of Islamic science in different regions and periods. Considering that thousands of original manuscripts remain untouched, this task seems daunting even though it may be rewarding to researches.

Finally, at the level of theory, there may be value in exploring the possibilities for new representations of the fate of Islamic science and new ways of conceptualising the field. Certainly, this study has added weight to previous arguments by critical researchers (like Saliba) that the ideas of decline-centeredness, and the conventional emphasis in narratives for the fate of Islamic science on presenting the history of Islamic science as that of failure, are inaccurate. The study has shown that they are no more than a social misconstruction of reality, and that Islamic science suffered different fates in different fields and times. With this in mind, researchers in the field of the history of Islamic science might want to explore what happened to other branches of Islamic science, and in the light of our findings what social, political, economic and religious factors could have influenced their fate. The fact that research in the history of Islamic science has hardly begun suggests that such a project to be challenging, but rewarding.

BIBLIOGRAPHY

Abdul-Aziz, L.A., "Does history repeat itself in medicine?" *Postgraduate Medical Journal*, 77, 913, 2001.

Acikgenc, A., *Scientific Thought And Its Burdens*. Istanbul: Fatih University Publications, 2000.

Agha, Zouhir M., *Bibliography of Islamic Medicine and Pharmacy = Bibliographie Der Islamischen Medizin Und Pharmazie*. London: E.J. Brill, 1983.

Ahmad, I., "Islam and Science: Religious Orthodoxy and the Battle for Rationality," *Arab Studies Quarterly*, 15, 3, 1993.

Al-Araki, A. M., *Ibn Khaldun: Discourse of the Method and Concepts of Economic Sociology* (University of Oslo, 1983). http://home.hio.no/~araki/arabase/ibn/khald201.html

Al-Dabbag, S. A., "Ibn al-Nafis and the pulmonary circulation," *Lancet*, 1, 1978.

Al-Hanafi, M., *Kashf-al-Thunoon* [Arabic]. Beirut: Dar al-Kutub al-'Ilmyya. *Al-Khateeb*. 'Library of Islamic History and Civilisation' CD ROM. Turath: Amman, 1999.

Al-Hassan, Ahmad. Y., "Factors behind the decline of Islamic science after the sixteenth century," in Sharifa Shifa Al-Attas (ed), *Islam and the Challenge of Modernity: Historical and Contemporary Contexts*. Kuala Lumpur: International Institute of Islamic Thought and Civilisation, 1996.

Al-Hassan, Ahmad Y., and Hill, Donald R., *Islamic Technology: An Illustrated History*. New York: Cambridge University Press, 1987.

Ali ibn, Ridwan, *et al*., *Medieval Islamic Medicine: Ibn Ridwan's Treatise, "On the Prevention of Bodily Ills in Egypt"*. Berkeley: University of California Press, 1984.

Al-Khateeb, *Library of Islamic History and Civilisation*. Vers. CD ROM. Computer Software. Turath, 1999, Arabic.

American Historical Association, *Statements on Standards of Professional Conduct*. Washington, D.C.: author, 1993.

Anawati, G., "Science," in P. M. Holt (ed), *The Cambridge History of Islam*. New York: Cambridge University Press, 1970.

Andrews, P. A., "Commodity and exchange in the Mongol Empire: A Cultural History of Islamic textiles." *The Economic History Review*, 52, 2, 1999.

Anees, M. A., "Islam and scientific fundamentalism." *New Perspectives Quarterly*, 10, 3, 1993.

Anonymous, 'Review Symposium: Edward Said's Orientalism,' and "Introduction" to Forum on Universalism and Relativism in South Asian Studies,' *Journal of Asian Studies*, xxxix, 3, 1980.

Arie, R., "Singular and Plural: The Heritage of Al-Andalus. (Spain under the Moors) (Al-Andalus: where three worlds met)." *UNESCO Courier*. Dec. 1991.

Armstrong, K., and Richard M. D., *Islam: A Short History.* Prince Frederick, MD: Recorded Books, 2002.

Armstrong, K., *Islam: A Short History.* 1st ed. New York: Modern Library, 2000.

Arnold, Sir T. and Guillaume, A., *The Legacy of Islam*. Oxford: The Clarenda Press, 1931.

Arnoud, M. *et al*., *Islamic Knowledge*. Princeton, N.J.: Films for the Humanities, 1988.

Ashby, E., "A Hippocratic Oath for the Academic Profession." *Minerva*, 7,1-2, 1968-69, pp.64-66.

Badawi, A., “The Toledo School” (Translators in Toledo, Spain during the Moorish rule) (Al-Andalus: where three worlds met). *UNESCO Courier*. Dec., 1991: 40(2).

Berggren, J. L., “Mathematics and Her Sisters in Medieval Islam: A Selective Review of Work Done from 1985 to 1995.” *Historia Mathematica*, 24, 1997, pp.407-40.

Berggren, J. L., *Episodes in the Mathematics of Medieval Islam*. New York: Springer-Verlag, 1986.

Bernal, J. D., *Science in History*. Harmondsworth: Penguin, 1954.

Bhatti, M. S., *Political and Cultural history of Islam*. Lahore: Dogarsons, 1996.

Blair, D., *The Pocket Macquarie Dictionary*. Queensland: The Jacaranda Press, 1982.

Bloch, S., “Moses Maimonides’ contribution to the biopsychological approach in clinical medicine,” *The Lancet*, 358, 9284, 2001.

Bloom J. and Sheila B., *Islam: A Thousand Years of Faith and Power*. New York: TV Books, 2000.

Bloom, J. and Sheila B., *Islamic Arts*. London: Phaidon Press, 1997.

Blue, G., *Joseph Needham's Contribution to the History of Science and Technology in China.* 25 June 2003. The United Nations University. Available: http://www.unu.edu/unupress/unupbooks/uu01se/uu01se0u.htm2003.

Booth, Wayne C., *The Vocation of a Teacher: Rhetorical Occasions 1967-1988*. Chicago: University of Chicago Press, 1988.

Boyer, Ernest L., *Scholarship Reconsidered: Priorities of the Professorate*. Princeton: The Carnegie Foundation for the Advancement of Teaching, 1990.

Bridgstock, M., Burch, D., Forge, J., Laurent, J., and Lowe, I., *Science, Technology and Society: An Introduction*. Cambridge: Cambridge University Press, 1998.

Bynum, W. F., and Roy P., *Companion Encyclopedia of the History of Medicine*. London: New York: Routledge, 1993.

Buchs M., "History of a discovery: Ibn al-Nafas and the lung circulation," *Med Secoli*, 7, 1, 1995.

Bullock, A., Stallybrass, O., and Trombley, S., *The Fontana Dictionary of Modern Thought*. Second Edition. Glasgow: Williams Collins Sons & Co. Ltd., 1990.

Bullock, A. and Stallybrass, O., *The Fontana Dictionary of Modern Thought*. London: Fontana Books, 1977.

Carra de Vaux, B., "Astronomy and Mathematics," in Sir Thomas Arnold and Alfred Guillaume (eds), *The Legacy of Islam*. Oxford: Clarendon Press, 1931.

Choudhury, M. A., *Studies in Islamic Science and Polity*. New York: Macmillan; St. Martin's Press, 1998.

Cohen, A. P., *The Symbolic Construction of Community*. London: Tavistock Publications, 1985.

Coppola, E. D., "The discovery of the pulmonary circulation: A new approach." *Bulletin of the History of Medicine*, 31, 1957.

Dalall, A., *Islamic paradigms for the relationship between science and religion* 2001. Available. http://kalam.org/papers/dallal.htm. 31 July 2001.

Dampier, Sir William C., *History of Science and its Relation with Philosophy and Religion*. Cambridge: Cambridge University Press, 1929.

David C. L., *The Beginning of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, 600 B.C. to A.D. 1450*," Chicago: The University Chicago Press, 1992.

Davies, M., Y., "Rethinking Knowledge: 'Islamisation' and the Future." *Futures*, April 1991, pp.231-247.

De Young, G., "Should Science be limited? Some Modern Islamic Perspectives." *The Monist*, 79, 2, 1996, p.280(14).

Djebbar, A., "A Panorama of Research on the History of Mathematics in Al-Andalus and the Maghrib between the Ninth and Sixteenth Centuries," in Jan P. Hogendijk and Abdelhamid I. Sabra (eds), *The Enterprise of Science in Islam: New Perspectives*. Cambridge: The MIT Press, 2003.

Djebbar, A., *Une Histoire de la science arabe, entretiens avec Jean Rosmorduc (A History of Arab Science -- Conversations with Jean Rosmorduc)* (Paris: Seuil, 2001), in David Tresilian, "Creeker than the Greeks," *Al-Ahram Weekly Online*, 10 - 16 January 2002, Issue No.568. http://weekly.ahram.org.eg/2002/568/bo5.htm p.xi.

Djebbar, A., 'On Mathematical activity in North Africa since the 9th century,' *AMUCHMA Newsletter*, 15, 1995, pp.3-24. Printed by the African Mathematical union.

Dorsey, G., "The Rise of Early Modern Science: Islam, China, and the West." Book Review. *Society*, 32, 3, 1995, p. 48(3).

Early, A., *Twelve Fas Faculty Members to Retire.* 1996. Available: http://www.news.harvard.edu/gazette/1996/06.13/TwelveFASFacult.html. September 2003.

Edwards, M., "Lord of the Mongols: Genghis. (Genghis Khan)." *National* Geographic, 190, 6, Dec.1996, p. 4(34).

Ehgamberdiv, S., "The Astronomical School of Ulugh Beg." *Sky & Telescope* 90.5 (Nov1995): 38(3).

Elena, A., "The decline of Islamic Science: A Re-interpretation." Trans. Sánchez-Bayo, F., *4th International Congress of the History of Arab Science*. Aleppo, Syria, 1987.

El-Gammal, S. Y., "Therapy and medicaments by Ibn al-Nafis," *Bull Indian Inst Hist Med Hyderabad*, 22, 2, July 1992.

Eric D. A., *Editorial Reviews*. 1992. Reed Business Information, Inc. Available: http://www.amazon.com/exec/obidos/tg/detail/-/0226482308/102-9684130-9657722?v=glance&s=books. 11 September 2003.

Esposito, John L., *The Islamic Threat: Myth or Reality*? 3rd ed. New York: Oxford University Press, 1999.

Esposito, John L., *Islam: The Straight Path*. 3rd ed. New York; Oxford: Oxford University Press, 1998.

France, J., "The Capture of Jerusalem." *History Today*, 47, 4, 1997.

Fuller, S., *Science*. Minneapolis: University of Minnesota Press, 1997.

Garfield, E., "How an Understanding of Science History Is Useful, Enriching, and Rewarding." *The Scientist*, 7, 24, 1993.

Ghalioungui P., "Was Ibn al-Nafis unknown to the scholars of the European Renaissance?" *Clio Med.*, 18, 1-4, 1983.

Ghamari-Tabrizi, B., "Is Islamic science possible?" *Social Epistemology*, 10, 3/4, 1996, pp.317-330.

Gibb, H. A. R., "The Influence of Islamic Thought on Medieval Europe." *Bulletin Of The John Raylands Library*, 38, 1955, pp.82-98.

Gillispie, Charles C. (ed), *Dictionary of Scientific Biography*. New York: Charles Scriber's Sons, 1976.

Gingerich, O., *The Great Copernicus Chase and Other Adventures in Astronomical History.* Cambridge: Cambridge University Press, 1992.

Gingerich, O., "Islamic Astronomy," *Scientific American*, 254, 1986.

Glassick, Charles E., Huber, Mary Taylor, and Maeroff, Gene I., *Scholarship Assessed: Evaluation of the Professorate*. San Francisco: Jossey-Bass Publishers, 1997.

Goodman, D., and Russell, C., A., *The Rise of Scientific Europe 1500-1800*. Kent: Hodder & Stoughton, 1991.

Goldstein, T., *Dawn of Modern Science*. Boston: Houghton Mifflin Co., 1980.

Goodwin, G., *Islamic Spain*. San Francisco: Chronicle Books, 1990.

Cook, G. C., "Does history repeat itself in medicine?" *Postgraduate Medical Journal*, 77, 906, Apr 2001.

Gordon, E. J., "William Harvey and the circulation of the blood," *South Medical Journal*, 84, 1991.

Grant, E., *The Foundations of Modern Science in the Middle Ages: Their Religious, Institutional, and Intellectual Contexts*. Cambridge: Cambridge University Press, 1996.

Grant, E., "When did modern science begin?" *American Scholar*, 66, 1, 1997, p.105 (9).

Grierson, R., "Islam and Science: Religious Orthodoxy and the Battle for Rationality," (Book reviews) *New Scientist*, 134, 1815, April 4, 1992.

Haddad, Yvonne Y., Byron H., and Ellison Banks F., *The Islamic Impact.* 1st ed. Syracuse, N.Y.: Syracuse University Press, 1984.

Hamarneh, S., "An Editorial: Arabic Science and Technology." *Journal for the History of Arabic Science*, 1, 1977, pp.3-7.

Hamilton, Richard F., *The social Misconstruction of reality: Validity and Verification in the Scholarly Community.* New Haven: Yale University Press, c1996.

Harrison, Teresa M., and Stephen, Timothy D., *The electronic journal as the heart of an online scholarly community*. (Networked Scholarly Publishing) *Library Trends*, 43, 4, Spring 1995, p.592 (17).

Hartner, W., "Nasir al-Din al-Tusi 's lunar theory," *Physis - Riv. Internaz. Storia Sci.* 11, 1969, pp. 287-304.

Hayes, J. R., *The Genius of Arab Civilisation*: *Source of Renaissance*. New York: New York University Press, 1975.

Haykal, Muhammad H., *The Life of Muhammad*. India: Crescent Publishing House, 1976.

Hill, Donald R., *Islamic Science and Engineering*. Islamic Surveys. Edinburgh: Edinburgh University Press, 1993.

Hillenbrand, R., *Islamic Architecture: Form, Function, and Meaning.* Casebound ed. New York: Columbia University Press, 1994.

Hitti, Phillip K., *Islam: A Way of Life*. London: Oxford University Press, 1970.

Hitti, Phillip K., *The Arabs: A Short History*. London: Macmillan, 1968.

Hodgson, Marshall G. S., *Rethinking World History: Essays on Islam, Europe and world history*. Cambridge: Cambridge University Press, 1993.

Hodgson, Marshall G. S., *The Venture of Islam*: *conscience and history in a world civilization*. New York: Knopf, 1976.

Hogendijk, Jan P., and Sabra, Abdelhamid I. (ed.), *The Enterprise of Science in Islam: New Perspectives*. Cambridge: The MIT Press, 2003.

Hoodbhoy, P., *Islam and Science: Religious Orthodoxy and the Battle for Rationality*. Pakistan: Zed Books, 1992.

Hoskin, M., *The Cambridge Concise History of Astronomy.* Cambridge: Cambridge University Press, 1999.

Hourani, A., *Islam in European Thought*. Cambridge: Cambridge University Press, 1991.

Huff, Toby E., *The Rise of Early Modern Science*. Cambridge: Cambridge University Press, 1993.

Huff, Toby E., "Science and Civilisations East and West." *Society*, 31,1, 1993, p.77 (3).

Hugonnard-Roche, H., "The Influence of Arabic astronomy in the medieval West" in Roshdi Rashed (ed), *Encyclopaedia of the history of Arabic sciences* London: Routledge, 1996.

Ibn Khaldun [1332-1406], *The Muqaddimah: An Introduction to History.* Trans. Franz R., 3 vols. New York: Pantheon Books, 1958.

Ibn Khaldun [1332-1406], Abdul Rahman M., *Muqaddimat Ibn Khaldun*. Arabic ed. 1 vols. Beirut: Dar Al-Qalam, 1984.

Imamuddin, S.M., *Some Aspects of the Socio-Economic and Cultural History of Muslim Spain.* Brill: Leiden, 1965.

`Inan M., A., *Tarikh al-Jami' al-Azhar* 1958. Available http://www.ims.uwindsor.ca/~azhar/HISTORY/Mamluk.html. 31 July 2002.

Institute, The Needham Research., *Joseph Needham 1900-1995.* 2003. Available: http://www.nri.org.uk/Joseph.htm. 24 June 2003.

Irving T.B., *Falcon of Spain.* Lahore: Muhammad Ashraf, 1962.

Irwin, R., "Muslim Response to the Crusade." *History Today*, 47,4, 1997.

James, David L., *Islamic Art: An Introduction.* London; New York: Hamlyn, 1974.

Janson, H. W., *History of Art : A Survey of the Major Visual Arts from the Dawn of History to the Present Day.* Englewood Cliffs, NJ New York: Prentice Hall;

Abrams, 1962.

Jacquart, D., "The influence of Arabic medicine in the medieval West," in Roshdi Rashed (ed), *Encyclopaedia of the history of Arabic sciences*. London: Routledge, 1996, vol.3.

Kahya , E., "Ibn al-Nafis and his work Kitab Mujiz al-Qanun," *Studies in the History of Medical Science*, 9,3-4, 1995.

Kasule Sr, Prof. Dr. Omar H., *Surgery in Islam: A historical and current reappraisal*, http://www.iiu.edu.my/medic/islmed/Lecmed/his-surg98.nov.html

Khan, Muhammad S., *Islamic Medicine*. London: Routledge & K. Paul, 1986.

Kennedy, E.S., "An Islamic Response to Greek Astronomy: Kitab Tad dil Hay at al-Aflak of Sadr al-Sharia," *The Journal of the American Oriental Society*, 117, n2, April-June 1997, p.384 (2).

Kennedy, E.S., Colleagues and Former Students. *Studies in the Islamic Exact Sciences*. Beirut: American University in Beirut, 1983.

Kennedy, E. S. "Late Medieval Planetary Theory," *Isis*, 57, 1966, pp.366-377.

Kilmer, Anne D., "On the Antiquity of Man's Commitment to Excellence in Scholarship." Paper presented to the California Scholarship Federation, Millbrae, Calif., Apr. 20, 1985.

King, David A., "World Maps for Finding the Direction and Distance of Mecca: Innovation and Tradition in Islamic Science." *Islamic Philosophy, Theology, and Science*, 36, 1999.

King, David A., "Proposal for an exhibition on Islamic science and technology," *UNESCO*, 1997, http://www.unesco.org/science/pao/exhib/islam2.htm#1

King, David A., *Islamic Astronomical Instruments*. London: Variorum, 1987, repr. Aldershot: Variorum, 1995.

King, David A., *Astronomy in the Service of Islam*. Aldershot: Variorum, 1993.

King, David A., *Islamic Mathematical Astronomy*. London: Variorum, 1986, 2nd rev. edn., Aldershot: Variorum, 1993.

King, David A., "The Astronomy of the Mamluks," *Isis*, 74, 1983, pp.531-55.

Knox, Ellis L., *History of Western Civilization* 1995. Available history.boisestate.edu/westciv/persian/victory.htm. Boise State University. 20 June 2001.

Kramer, M., "Coming to terms: Fundamentalists or Islamist?" *Middle East Quarterly*, Spring 2003, pp.65-77.

Krisciunas, K., *Astronomical centres of the World.* Cambridge: Cambridge University Press, 1988.

Kunitzsch, P., "The Transmission of Hindi-Arabic Numerals Reconsidered," in Jan P. Hogendijk and Abdelhamid Sabra (eds), *The Enterprise of Science in Islam: New Perspectives*. Cambridge: The MIT Press, 2003.

Lane-Poole, S., *The Story of the Moors in Spain.* Baltimore: Black Classic Press, 1887/reprint 1990.

Lapidus, I. M., "State and religion in Islamic Societies," *Past & Present*, 151, 1996, p. 3(25).

Lapidus, I. M., *A History of Islamic Societies*. New York: Cambridge University Press, 1988.

Lee, J., "The long lost land. (Islamic Andalusia)." *The Middle East*, 223, 1993, p. 45(1).

Lewis, B., "The West and the Middle East." *Foreign Affairs*, 76, 1997, pp.114-30.

Lewis, B., *Islam and the Arab World, Faith, People, Culture*. New York: Knopf, 1976.

Lewis, P., "The History of Science," *American Scientist*, 91, 3, 2003, p.265(2).

Lindholm-Romantschuk, Y., *Scholarly Book Reviewing in the Social Sciences and Humanities*. London: Greenwood Press, 1998.

Lings, M., *Muhammad: His Life Based on the Earliest Sources*. Colombo: George Allen & Unwin, 1983.

Livingstone, J. W., "Science and the Occult in the thinking of Ibn Qayyim Al-

Jawziyya," *The Journal of the American Oriental Society*, 112, 4, 1992, p.598 (13).

Lynton, Ernest A., *Making the Case for Professional Service*. Washington, D.C.: American Association for Higher Education, 1995.

Maalouf, A., *The Crusades Through Arab Eyes*. New York: Schocken Books, 1984.

Mahdi, M., *Ibn Khaldun's Philosophy of History*. Chicago: University of Chicago Press, 1971.

Maimonides, M., *Regimen Sanitatis: the preservation of youth--essays on health* New York: Philosophical Library, 1958.

Makdisi, G., "On the origin and development of the college in Islam and the West," in Khalil I. Semaan (ed), *Islam and the Medieval West*. New York, 1980: 26-49.

Massry, S.G., "Maimonides: physician and nephrologist," *Am J Nephrol*, 14, 4-6, 1994.

McClellan III, James, E., and Dorn H., *Science and Technology in World History: An Introduction*. London: The John Hopkins University Press, 1999.

Merton, Robert K., "Science and Technology in a Democratic Order," *Journal of Legal and Political Sociology*, 1. Reprinted in Merton, *Social Theory and Social Structure*. New York: Free Press, 1968.

Mettler, C. C., *History of medicine*. Philadelphia: Blakiston Co., 1974.

Meyerhof, M., "Science and Medicine," in T. Arnold and A. Guillaume (eds), *The legacy of Islam*. London: Oxford University Press, 1931.

Miller, M., Miller, S. M., and Runciman, W. G., *Max Weber*. Thomas Y. Crowell

Company, 1963.

Mirza, M.R., and Siddiqi, M.I., *Muslim Contribution to Science*. Lahore: Kazi Publications, 1986.

Moore, B., *The Australian Oxford Dictionary.* Oxford: Oxford University Press, 1999.

Mordechai, F., "Decline and Fall: Arabic Science in Seventeenth-Century England," in Sally P. Ragep (ed), *Tradition, Transmission, Transformation*. Leiden: E. J. Brill, 1996, pp.441-69.

Morelon, R., "General survey of Arabic astronomy," in Roshdi Rashed (ed.). *Encyclopedia of the History of Arabic Science*. London: Routledge, 1996, vol.1.

Musallam, B., *The Arabs*. London: Collins, 1983.

Nadvi, S. H. H., *Medical Philosophy in Islam and the contributions of Muslims to the Advancement of medical Sciences*. Durban: Academia, 1983.

Nagamia Husain F., "Islamic Medicine: History and Current Practice," *International Institute of Islamic Medicine.* http://www.iiim.org/. 21 October 2003.

Nasr, Seyyed H., *Islam and Modern science*. http://web.mit.edu/mitmsa/www/NewSite/libstuff/nasr/nasrspeech1.html. 1999.

Nasr, Seyyed H., *Islamic science: An illustrated Study*. Westerham: Westerham Press, 1976.

Nasr, Seyyed H., *An Annotated Bibliography of Islamic Science*. Tehran: Imperial Iranian Academy of Philosophy, 1975.

Nasr, Seyyed H., *Science and Civilisation in Islam*. New York: Plume Books, 1968.

Needham, J., “The Historian of Science as Ecumenical Man: A Meditation in the Shingon Temple of Kongosammai-in on Koyasan,” in Nakayama and Sivin (eds), *Chinese Science: Explorations of an Ancient Tradition.* Cambridge: MIT Press, 1973.

Needham, J., *Science and Civilisation in China*. Vol. 1. Cambridge: Cambridge University Press, 1965.

Osman, B., *The History and Philosophy of Islamic Science*. Cambridge: Islamic Texts Society, 1999.

Overbye, D., “How Islam Won, and Lost, the Lead in Science.” *Science Times*, October 30, 2001.

Pavlovic, B., “ Maimonides, a physician in the 12 century. Contribution to the history of medical ethics and deontology” [Article in Serbo-Croatian (Cyrillic)], *Srp Arh Celok Lek*, 128, 5-6, 2000.

Persaud, T. V., “Historical development of the concept of a pulmonary circulation,” *Canadian Journal of Cardiology*, 5,1, Jan-Feb 1989.

Pickthall, M. M., *The cultural Side of Islam*. Lahore: Muhammad Ashraf Publisher, 1961.

Pines, S., “Philosophy,” in Holt, P. M, Lambton, K.S., and Lewis, B. (eds), *The Cambridge History of Islam.* London: Cambridge University Press, 1970.

Pines, S., “What was original in Arabic Science,” in Crombie, A. C. (ed), *Scientific Change*, 1963, pp.81-205.

Porter, R., “Heart and soul.” *New Scientist*, 170, 2290, May 12, 2001.

Press, The MIT., *Science in History*. 2003. Available: http://www-mitpress.mit.edu/catalog/item/default.asp?sid=C194F6D6-2B09-4514-ACE1-498CFB912E76&ttype=2&tid=7102. 24 June 2003.

Prioreschi, P., Henry A. A., and William B. B., *A History of Medicine.* 1st ed. Lewiston N.Y.: Edwin Mellen Press, 1991.

Pyenson, L., "The History of Science," *American Scientist*, 91, 3, 2003.

Qura'a, S., (1968), *Tarikh al-Azhar fir Alf `Am* http://www.ims.uwindsor.ca/~azhar/HISTORY/Mamluk.html

Qadir, C.A., *Philosophy and science in the Islamic world*. London: Croom Helm Ltd., 1988.

Rahman, A., "Sixteenth - and Seventeenth - Century Science in India and Some Problems of Comparative Studies," in Mikulas Teich and Robert Young (eds), *Changing Perspectives in the History of Science: Essays in Honour of Joseph Needham.*. London: Heinemann, 1973.

Ragep, F J., *Nasir al-Din al-Tusi Memoir on Astronomy*, 2 vol. New York: Springer-Verlag, 1993.

Rashed, R. (ed), *Encyclopedia of The History of Arabic Science*. Vol. 1. 3 vols. London: Routledge, 1996.

Rashed, R. (ed.), *The development of Arabic Mathematics: Between Arithmetic and Algebra*. Translated by A. F. W. Armstrong. Dordrecht: Kluwer Academic Publishers, 1994.

Rassool, G. H., "The crescent and Islam: healing, nursing and the spiritual dimension. Some considerations towards an understanding of the Islamic perspective on caring," *Journal of Advanced Nursing*, 32, 6, 2000, p.1476.

Ravetz, J. R., "Prospects for an Islamic science," *Futures*, April 1991, pp.262-272.

Renan, E., “Islamism and science,” in Ernest Renan (ed), *Poetry of the Celtic Race and Other Studies*. London: W.Scott, 1896.

Robinson, F., “Knowledge, its Transmission and the Making of Muslim Societies,” in Robinson, F (ed), *The Cambridge Illustrated History of the Islamic World*. London: Cambridge University Press, 1996.

Robinson, F. (ed.), *The Cambridge Illustrated History of the Islamic World*. London: Cambridge University Press, 1996.

Roesenthal, F., *The Classical Heritage in Islam*. London: Routledge & Kegan Paul, 1975.

Rogers, G. S., “An examination of historians’ explanations for the Mongol withdrawal from East Central Europe (in 1242),” *East European Quarterly*, 30,1, Spring 1996, p. 3(24).

Ross-Owen, D.G., and Sardar, Z., ‘Social Change in Islam – The Progressive Dimension’ and ‘The Quest for A new Science’ respectively. *The Muslim Institute Papers*. Slough: The Open Press, 1976.

Sabbaghi, R., “The Arab forebears of the European Renaissance (interview with French historian and philosopher Alain de Libera) (Interview),” *UNESCO Courier*, Feb. 1997: 4(6).

Sabra, Abdelhamid I., “Ibn al-Haytham’s Revolutionary Project in Optics: The Achievements and the Obstacle,” in Hogendijk, Jan P. and Sabra, Abdelhamid I (ed.), *The Enterprise of Science in Islam: New Perspectives*. Cambridge: The MIT Press, 2003.

Sabra, Abdelhamid I., “Configuring the Universe: Aporetic, Problem Solving, and Kinematic Modelling as Themes of Arabic Astronomy,” *Perspectives on Science*, 6, Fall 1998, i3.

Sabra, Abdelhamid I., *Optics, Astronomy and Logic -- Studies in Arabic Science* *and Philosophy*, Aldershot (U.K.): Variorum, 1994

Sabra, Abdelhamid I., "The appropriation and subsequent naturalization of Greek science in Medieval Islam: A preliminary statement," *History of Science*, 25,68, 1987, pp.223-243.

Sabra, Abdelhamid I., "The Andalusian Revolt Against Ptolemaic Astronomy," Mendelsohn, E. (ed), *Transformation and Tradition in the Sciences.* New York: Cambridge University Press, 1984.

Said, E., *Orientalism.* London: Routledge and Kegan Paul, 1978.

Said, E., *The World, the Text and the Critic*. Harvard: Harvard University Press, 1983.

Said, E., *Representation of the Intellectual*. London: Vintage, 1994.

Saidi F., "Ibn Al-Nafis," *Journal of the Royal Society of Medicine*, 91, 9, 1998.

Saliba, G., "Arabic Science Historian George Saliba Rejects Common Explanations of Decline of Science in Islamic World." *Columbia News Video Brief*, July 1 2002. http://www.columbia.edu/cu/news/media/02/georgeSaliba/.

Saliba, G., "Greek Astronomy and the Medieval Arabic Tradition," *American Scientist*, 90, 2002, pp.360-67.

Saliba, G., *Rethinking the Roots of Modern Science: Arabic Scientific Manuscripts in European Libraries*, Occasional Paper, Centre for Contemporary Arabic Studies, Georgetown University, 1999.

Saliba, G., *The Origin and Development of Arabic Scientific Thought*, [Arabic]. Lebanon: Balamand University, 1998.

Saliba, G., "Arabic Planetary Theories after the Eleventh Century AD," in Roshdi

Rashed (ed), *Encyclopaedia of the History of Arabic Science*. London: Routledge, 1996, pp. 58-127.

Saliba, G., "Writing the history of Arabic astronomy: problems and differing perspectives," *The Journal of the American Oriental Society*, 116, 4, Oct-Dec 1996.
http://web6.infotrac.galegroup.com/itw/infomark/796/299/33216084w6/purl=rc1_EAIM_0_A19404331&dyn=3!xrn_9_0_A19404331?sw_aep=griffith.

Saliba, G., *A History of Arabic Astronomy: Planetary Theories During the Golden Age of Islam*, New York University Press, 1994, paper, 1995.

Saliba, G., "Early Arabic Critique of Ptolemaic Cosmology: A Ninth-Century Text on the Motion of the Celestial Spheres," *Journal for the History of Astronomy*, 25, 1994, pp115-141.

Saliba, G., "A Sixteenth-Century Arabic Critique of Ptolemaic Astronomy: The Work of Shams al-Din al-Khafri," *Journal for the History of Astronomy*, 25, 1994, pp.15-38.

Saliba, G., *A History of Arabic Astronomy: Planetary Theories During the Golden Age of Islam.* New York University Studies in near Eastern Civilization; No. 19. New York: New York University Press, 1994.

Saliba, G., "Al-Qushji's Reform of the Ptolemaic Model for Mercury," *Arabic Sciences and Philosophy*, 3, 1993, pp.161-203.

Saliba, G., "The Role of the Astrologer in Medieval Islamic Society," *Bulletin d'Etudes Orientales*, 44, 1992, pp.45-68.

Saliba, G., "The Astronomical Tradition of Maragha: A Historical Survey and Prospects for Future Research,' *Arabic Sciences and Philosophy*, 1, 1991, pp.67-99.

Saliba, G., *Kitab al-Hya'ah – The astronomical work of Mu'ayyad al-din al-'Urdi*. Centre for Arab Unity Studies, 1990.

Saliba, G., "A Medieval Arabic Reform of the Ptolemaic Lunar Model," *Journal for the History of Astronomy*, 20, 1989, pp.157-164.

Saliba, G., "Theory and Observation in Islamic Astronomy: The work of Ibn al-Shatir," *Journal for the History of Astronomy*, 18, 1987, pp.35-43.

Saliba, G., "The Development of Astronomy in Medieval Islamic Society," *Arab Studies Quarterly*, 4, 3, 1982, p.223.

Salman, A. L., "The growth and decline of Islamic Astronomy." *Islamiyyat*, 14, 1993, pp.13-31.

Samian, A. L., "The growth and Decline of Islamic astronomy," *Islamiyyat*, 14, 1993, p.19.

Sardar, Z., *Orientalism*. Buckingham: Open University Press, 1999.

Sardar, Z., "Logic and Laws." *Nature*, 368, 1994, pp.376-378.

Sardar, Z., "Why Islam needs Islamic science," *New scientist*. 94, 1982, pp.25-8.

Sardar, Z., Davies, M.W. and Nandy, A. *Barbaric Others: A Manifesto on Western Racism*. London: Pluto Press, 1990.

Sarton, G., *Introduction to The History of Science*. New York: Krieger. Reprint of the edition published for the Carnegie Institution of Washington by the Williams & Wilkin Company, 1927-48.

Saunders, J. J., *Muslims and Mongols: Essays Medieval Asia*. University of Canterbury: Whitcoulls Ltd, 1977.

Savage-Smith, E., "The Practice of Surgery in Islamic Lands: Myth and Reality," in P. Horden and E. Savage-Smith (eds), *The Year 1000: Medical Practice at the*

End of the First Millennium, [*Social History of Medicine*, XIII,2]. Oxford: Oxford University Press, 2000.

Savage-Smith, E., "The Exchange of Medical and Surgical Ideas between Europe and Islam," in J.A.C. Greppin, E. Savage-Smith, and J.L. Gueriguian (eds), *The Diffusion of Greco-Roman Medicine into the Middle East and the Caucasus*. Delmar, NY: Caravan Press, 1999.

Savage-Smith, E., "Europe and Islam," in Irvine Loudon (ed), *Western Medicine: An Illustrated History*. Oxford: Oxford University Press, 1997.

Savage-Smith, E., "Medicine," in Roshdi Rashed (ed), *Encyclopaedia of the history of Arabic sciences*. London: Routledge, 1996, vol.3.

Savage-Smith, E., "Attitudes Toward Dissection in Medieval Islam," *Journal of the History of Medicine and Allied Sciences*, 50, 1995.

Savage-Smith, E., "Gleanings from an Arabist's Workshop: Current Trends in the Study of Medieval Islamic Science and Medicine," *Isis*, 79, 1988, pp.246-72.

Savage-Smith, E., "Ibn al-Nafis's Perfected book on ophthalmology and his treatment of trachoma and its sequelae," *Journal of the History of Arabic Science*, 1980, 4.

Savage-Smith, E., *Islamic Medical Manuscripts at the National Library of Medicine*, http://www.nlm.nih.gov/hmd/arabic/welcome.html.

Savory, R. M. (ed.), *Introduction to Islamic Civilisation*. Cambridge: Cambridge University Press, 1976.

Sayili, A., (1960), "The causes of the decline of scientific work in Islam," *The Observatory in Islam and its place in the general history of the observatory.* Ankara: The Turkish Historical Society, Appendix II, Series VII, No. 38, 1960: 407-429,

Sayili, A., *The Observatory in Islam and its place in the general history of the* *observatory*. Ankara: Türk Tarih Kurumu Basimevi, 1960.

Soubani, Ayman O., and Khan, Farouque A., "The discovery of the pulmonary circulation revisited." New England Medical Center: Tufts University Scholl of Medicine. www.kfshrc.edu.sa/annals/152/mh9422ar.html.

Swerdlow, N., and Neugebauer, O., *Mathematical Astronomy in Copernicus's "De revolutionibus.* New York: Springer Verlag, 1984, cited in Toby Huff, *The Rise of Early Modern Science*. Cambridge: Cambridge University Press, 1993.

Serres, M. (ed.), *A History of Scientific Thought*. Oxford: Blackwell Publishers Ltd, 1995.

Sertima, I. V., *Golden Age of the Moor.* New Brunswick: African Civilisations Ltd., Inc., 1992.

Shahid, I., 'Pre-Islamic Arabia,' in Holt, P. M., Lambton, K.S., and Lewis, B., (eds), *The Cambridge History of Islam.* London: Cambridge University Press, 1970.

Shahid, S., M., *Islamic History and Culture* Vol –1. Lahore: Emporium, 1992.

Sharif, M.M., *History of Muslim Philosophy*. Wiesbaden: Otto Harrassowitz, 1963.

Shils, E., *The Academic Ethic*. Chicago: University of Chicago Press, 1984.

Smith Jr., J. M., "Mongols and Mamluks: The Mamluk-Ilkhanid war, 1260-1281" (book reviews), *The Journal of the American Oriental Society*, 118,1, 1998, p.54(9).

Sopova, J., "Ulugh Beg, the astronomer-king." *UNESCO Courier*, 1994, p.47(1).

Sorokin, P. A., and Merton, R. K., "The course of Arabian Intellectual development, 700-1300 A.D. A study in Method" *Isis*, l, 22, 1934-35, pp. 516-

524.

Sowell, T., *Knowledge and Decisions*. New York: Basic Books, 1980.

Springborg, R., "Multiculturalism and Orientalism: The role of values in academic study of the Middle-East," *Asian Studies Review*, 15, 2, 1991.

Staceqicz-Sapuntzakis, M. and Pontecorvo-Martonffy, A., "In defence of Copernicus. (Letters to the Editors)," *American Scientist*, 90, 6, Nov-Dec 2002, p.492 (1).

Teich, M. and Young, R. (eds.), *Changing Perspectives in the History of Science: Essays in Honour of Joseph Needham*. London: Heinemann, 1973.

Teresa M. H., and Timothy D. S., *The electronic journal as the heart of an online scholarly community*. (Networked Scholarly Publishing) *Library Trends*, Spring 1995 v43 n4 p592 (17).

The American Heritage® Dictionary of the English Language. Fourth Edition. Boston: Houghton Mifflin Company, 2000.

The Merriam-Webster Dictionary On Line, http://www.m-w.com/cgi-bin/dictionary

The Needham Research Institute, *Joseph Needham 1900-1995*. Available: http://www.nri.org.uk/Joseph.htm. 24 June 2003.

Tresilian, D., "Greeker than the Greeks," *Al-Ahram Weekly Online*. 10 - 16 January, Issue No.568, 2002. http://weekly.ahram.org.eg/2002/568/bo5.htm.

Turner, Bryan S., *Orientalism, Postmodernism & Globalism*. New York: Routledge, 1994.

Turner, H. R., *Science in Medieval Islam: An illustrated introduction*. Austin: University of Texas Press, 1995.

Ullmann, M., *Islamic Medicine*. Edinburgh: Edinburgh University Press, 1978.

UNESCO. "Islam, Philosophy and Science". France: The UNESCO Press, 2000.

Vernet, J., "The pursuit of learning. (Moorish rule in Spain) (Al-Andalus: where three worlds met)," *UNESCO Courier*, Dec. 1991, p.38(2).

Von Grunebaum, G. E., *Medieval Islam: A Study in Cultural Orientation*. Chicago: University of Chicago press, 1946.

Webster's Revised Unabridged Dictionary, © 1996, 1998 MICRA, Inc.

Weiss, S. and Wesley, K., 'Postmodernism and Its Critics.' Department of Anthropology College of Arts and Sciences: The University of Alabama. http://www.as.ua.edu/ant/Faculty/murphy/436/pomo.htm

Weldon, Stephen P., "Introduction." *Isis*, 93,4, 2002, Sv(5).

Wheeler, A.G., "The Pressure to Publish promotes disreputable science," *The Scientist*, 3, 14, 11, Jul. 10, 1989. http://www.the-scientist.com/yr1989/jul/opin_890710.html

Wickens, G. M., "The Middle East as world centre of science and medicine" in Savory, R. M. (ed), *Introduction to Islamic Civilisation*. Cambridge: Cambridge University Press, 1976.

William S. Brockman, N. L., Carole L. P. and Tonyia J. T., *Scholarly Work in the Humanities and the Evolving Information Environment*. Council on Library and Information Resources (CLIR) and the Digital Library Federation (DLF), December 2001. http://www.clir.org/pubs/reports/pub104/contents.html

William, W., and Nicholas, W., *Betrayers of the Truth*. New York: Simon and Schuster, 1985.

Wilson, Wendell E., "Antecedents (The History of Mineral Collecting: 1530-1799)," *The Mineralogical Record*, 25, 6, Nov-Dec 1994.

Wise, G., "Assessing the Scholarship of Engagement: Adapting Scholarship Reconsidered and Scholarship Assessed to Evaluate Outreach Faculty for Promotion and Tenure," *University of Wisconsin-Extension*, 01/24/2002, http://www1.uwex.edu/secretary/$WPM79FB/index.htm.

Young, M. J. L., Latham, J. D. and Serjeant, R. B. (eds), *Religion, Learning and Science in the Abbasid Period*. Cambridge: Cambridge University Press, 1990.

Zaimeche, S., "A Review on Muslim Contribution to Astronomy." Foundation for Science, technology and Civilisation, 2002. http://www.muslimheritage.com/topics/default.cfm?ArticleID=233.

Ziman, J., *The Force of Knowledge The Scientific Dimension of Society*. Cambridge: Cambridge University Press, 1976.

Zürcher, E., "In Memoriam: Dr Joseph Needham, 1900-1995," *The International Institute for Asian Studies*, 1995. Available: http://www.iias.nl/iiasn/iiasn5/eastasia/needham.html. 21 June 2003.