



The Oxford Handbook of the Economics of Religion

Rachel M. McCleary (ed.)

<https://doi.org/10.1093/oxfordhb/9780195390049.001.0001>

Published: 2011

Online ISBN: 9780199940332

Print ISBN: 9780195390049

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CHAPTER

4 Islam and Human Capital Formation: Evidence from Premodern Muslim Science

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<https://doi.org/10.1093/oxfordhb/9780195390049.013.0004> Pages 81–92

Published: 18 September 2012

Abstract

Given the rich scientific tradition of the Muslim world, current levels of scientific production in predominantly Muslim countries are surprisingly low. A recent survey of the state of scientific production in Muslim countries found that forty-six predominantly Muslim countries produced 1.17 percent of the world's science literature between 1997 and 2007. The historical record provides evidence that religious diversity and religious tolerance helped constrain Islam's conservative elements for hundreds of years. This article examines the extent to which the behavior of Muslim religious authorities helps explain the evolution of Muslim scientific development in the premodern era. It begins by providing a brief overview of scientific production throughout Islamic history and then examines the role of religion in both the flourishing and stagnation of Muslim science. The conclusion provides suggestions for future research and examines the extent to which the historical evolution of Islam provides lessons for encouraging scientific progress today.

Keywords: [Islam](#), [science](#), [Muslim countries](#), [religion](#), [scientific development](#), [religious tolerance](#), [religious diversity](#)

Subject: [Labour and Demographic Economics](#), [Economic History](#), [Economics](#)

Series: [Oxford Handbooks](#)

Collection: [Oxford Handbooks Online](#)

1. Introduction

Given the rich scientific tradition of the Muslim world, current levels of scientific production in predominantly Muslim countries are surprisingly low. A recent survey of the state of scientific production in Muslim countries found that forty-six predominantly Muslim countries produced 1.17 percent of the world's science literature between 1997 and 2007 (Hoodbhoy 2007). In comparison, India and Spain, respectively, produced 1.66 percent and 1.48 percent of the world's total intellectual output over this period. Other metrics give similar impressions: Muslim countries underproduce in science. A millennium ago, the position of Muslim-ruled countries in world scientific production looked very different. Muslim countries led the world, and Arabic was the lingua franca of scientific production.

This chapter examines the extent to which the behavior of Muslim religious authorities helps explain the evolution of Muslim scientific development in the premodern era. It begins by providing a brief overview of scientific production throughout Islamic history and then examines the role of religion in both the flourishing and stagnation of Muslim science. The conclusion provides suggestions for future research and examines the extent to which the historical evolution of Islam provides lessons for encouraging scientific progress today.

2. A Brief History of Muslim Science

A cursory examination of a list of English words derived from Arabic indicates the extent of Muslim medieval scientific development.¹ Among other scientific loan words from Arabic that continue to be used today, Muslim scientists gave English the terms *alcohol*, *algebra*, *algorithm*, *amalgam*, *almanac*, *azimuth*, *chemistry*, and *zero*.

Muslim medieval scientific advances included the development of algebra, trigonometry, and chemistry; the widespread use of the experimental method; and the development of the astronomical models used by Copernicus (Saliba 2007). In many fields, Muslim scientific accomplishments greatly surpassed those achieved in China.² Islam's medieval scientific development is all the more striking because it appeared so "European."³

Muslims pioneered many of the empirical and mathematical techniques that proved central to European scientific development, and Muslim thinkers even had their own "enlightenment." European thinkers did not surpass eleventh-century Muslim scientific and technological developments until well into the Renaissance—after more than 300 years of continuous study of translated Muslim scientific works.⁴

Bernard Lewis sums up medieval scientific developments in the Muslim world. He notes that "for most of the Middle Ages, it was neither the older cultures of the Orient nor the newer cultures of the West that were the majors centers of civilization and progress, but the world of Islam in the middle. It was there that old sciences were recovered and developed and new sciences created" (Lewis 2003: 156).

2.1 Did Muslim Science Stagnate?

Traditionally, scholars have held that Muslim science began to stagnate somewhere between the eleventh and thirteenth centuries. Although some scholars, most prominently Saliba (2007), have recently questioned this traditional story, a considerable amount of evidence suggests that scientific activity did decline in the Muslim world between the eleventh and thirteenth centuries.⁵ Possible explanations for this stagnation include an increase in resistance by the religious authorities to the study of the sciences, the start of the First Crusade (1095), and the Mongol invasions of the thirteenth century.

However, the Mongol invasions and the start of the First Crusade do not seem to explain the stagnation of scientific activity across the Muslim world. Egypt and North Africa, for example, were never overrun by the Mongols or by Crusaders and nonetheless experienced scientific stagnation during this period.

The remainder of this chapter focuses on the role religious elites played in both the rise and decline of Muslim science. I argue that competition between Islam and the religions in the lands it conquered can both explain the sudden rise in the interest of the religious elites toward the rational sciences following the Muslim conquests as well as their change in attitudes in the later centuries.

3. Religion and Scientific Development in Islam

3.1 A Conflict between Religion and Science?

The secondary literature debates the importance of religion in constraining the development of science in the Islamic world (for an introduction to this debate, see Sabra 1987, Huff 1993, Saliba 1997, Gutas 1998 and references therein). Although the interface between religion and science in the Islamic world remains an open topic of research, primary sources provide overwhelming evidence that many prominent scholars throughout Islam's history saw tensions between religion and scientific study.⁶ A sample of quotes from prominent Muslim scholars over eight centuries helps illustrate this point. For example, in the nineteenth century, Jamal al-din al-Afghani (1838–97), a prominent Muslim reformer, stated that “it is true, the Muslim religion has sought to strangle science and stop progress. Islam has succeeded in curbing [Islam's] philosophical movement and discouraging people from pursuing scientific truth” (Renan 2003: 38–39).

Several centuries earlier, another Muslim scholar made similar observations. Hajji Khalifa (1599–1658), a renowned Ottoman scholar, summarized the opinion of many religious authorities toward the “rational” sciences during his lifetime: “for you hear them state that the study of logic is prohibited [*yaquluna bi-tahrim al-mantiq*] even though logic is at the heart of science and they prohibit philosophy even though it seeks after the knowledge of the truth [...] the religious authorities [*a'imma*] prohibited the teaching of [...] the sciences” (Khalifa 1835: 54–55).

Ibn Taymiyya (1263–1328), a prominent religious scholar writing around the time Muslim science was in decline, stated that “philosophers are not Muslims. A prominent judge in our times was asked: ‘Is Ibn Sina [Avicenna] one of the Muslim philosophers?’ Thereupon he replied: ‘Islam has no philosophers’” (Hallaq 1993: 113).

Al-Ghazali (1058–1111), perhaps Islam's most renowned religious scholar, when speaking of those who studied mathematics, noted that “he who studies mathematics is amazed by its precision and proofs. He then takes a more positive view of philosophy and reckons that all of the rational sciences are as clear and trustworthy as mathematics [...] and he says: if religion were true, then the philosophers would have proved its veracity with their precise methods [...] we have seen many deviate from the truth [i.e., Islam] in this manner” (Al-Ghazali 1971: 21–22).

Although I have limited the exposition to a few of Islam's most well-known thinkers, one could fill a book with such quotes. The primary sources demonstrate—at the very least—that many of Islam's most prominent scholars and religious authorities thought and behaved as if a conflict between religion and science existed.

The large body of evidence detailing resistance of many religious authorities to the study of science has led a prominent historian of Islamic science to state that “whether the eventual decline of the rational sciences in

medieval Islam was solely, or largely, due to religious opposition [...] remains an open question” (Sabra 1987).

3.2 When and Why Did the Conflict Arise?

p. 85 Following the Muslim conquests (632–732 C.E.), many Muslim religious elites⁷ were suspicious of Hellenistic learning (Goldziher, 1916: 186–187; Sabra 1987: 231; Huff ↵ 1993: 68). They viewed the use of rational methods as an unnecessary addition to the Islamic sciences.⁸

Al-Kindi (801–873), one of Islam’s most prominent philosophers, in his treatise on first philosophy documents the resistance of Muslim religious authorities to the study of the rational sciences at an early date. He relates that:

[many religious authorities] are strangers to the truth [... they view those who study the sciences as] audacious, harmful opponents; [and the religious authorities defend] their spurious thrones which they installed undeservedly for the purpose of gaining leadership and [gain] in religion [... they] resist the acquisition of knowledge of the real nature of things and call it unbelief. (Kindi 1974: 58–59)

It seems that many Muslim religious authorities resisted the widespread study of science from the start. Kindi believed that these leaders opposed the study of the sciences for the purpose of obtaining “leadership and gain” (Kindi 1974: 58–59).

Although a detailed overview of the place of religion in Muslim society is not possible here,⁹ religious leaders had much to gain from a large and loyal following. George Makdisi has summarized these potential gains by noting that “greater membership led to greater influence in the community; and influence led, in turn, to greater financial support from those in power who were interested in controlling the masses” (Makdisi 1991: I, 45).

Kindi’s observation that many religious leaders resisted the study of the sciences because these posed a threat to the religious leaders’ “spurious thrones” suggests that religious leaders feared that the sciences would lead some to disregard their teachings. This decrease in following would in turn lessen their societal influence and financial support from political authorities.

3.3 Tolerance, Religious Competition, and Reason

Despite the belief that the widespread study of rationalistic methods often worked to undermine their authority, even the most conservative religious elites often tolerated the study of these methods for centuries. Ibn ‘Aqil, an eleventh-century Hanbali scholar, suggests why the religious elites tolerated the study of these sciences. He noted that philosophers and dialectical theologians (*mutakallimun*) should be “spared when they use their knowledge to defend Islam [from the attack of non-Muslims and heretics]” (Makdisi 1997: 207).

p. 86 The sources suggest that Muslim religious elites became interested in the study of logic after the conquered populations objected to Muslim proselytizing in logical terms. Although many religious authorities remained skeptical of the study of logical methods, ↵ they “understood that one could not reasonably expect to be successful in argumentation with non-Muslims or heretics, unless willing to argue on the basis of premises acceptable to one’s adversary” (Makdisi 1997: 73). As a consequence, Muslim religious scholars sanctioned the study of logic to better debate with adherents of other faiths.

Muslim religious authorities were constrained from forcibly silencing the local populations by numerical realities and by Muslim law.¹⁰ At the same time, these religious authorities stood to gain from a larger and

more loyal following. Though there is little doubt that the vast majority of the population did not understand the arguments deployed in religious debates,¹¹ the evidence suggests that the population did value the relative intellectual standing of Islam when deciding whether to convert and which Muslim law school to affiliate with.¹² Thus, Muslim religious leaders could expect to gain supporters when Muslim scholars outperformed other religions in public debates.

In sum, following the conquests, Muslim religious elites faced a difficult decision. They could allow their followers to study logical methods to perform well in debates, making their sect¹³ more attractive to potential converts. The study of logical methods, in turn, would lead some to question the authority of the religious elites. Alternatively, they could attempt to prohibit the study of logical methods. This would protect religion from the skepticism of philosophers but might also diminish the chances of gaining converts should Islam appear inferior to other faiths.

3.4 From Logic for Debates to Science

The previous discussion suggests that a religious authority should encourage his entourage to study logical methods as long as the benefits of doing so outweigh the costs. Immediately following the conquests, it appears that the benefits of encouraging the study of logic exceeded the costs.

Religious authorities across the various legal schools (*madhhabs*) encouraged students to study logical methods as developed in *‘ilm al-kalam* (the science of dispute or discussion) to defend the maddhab against attacks from both non-Muslims and other Muslim schools of thought. Schools that resisted such logical methods (such as the *zahiri* school) eventually became extinct. This suggests that the use of logical methods did affect the ultimate success of a school.

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Although some schools never supported the study of logical methods, religious authorities generally tolerated the study of *‘ilm al-kalam* as long as it was seen as useful. The study of *‘ilm al-kalam*, in turn, was seen as a stepping stone to the other rational sciences.¹⁴ Indeed, many natural philosophers (premodern scientists) practiced their profession under the guise of *‘ilm al-kalam*.¹⁵ Although the tolerance of the study of *‘ilm al-kalam* and logical methods was not a sufficient condition for the emergence of scientific studies, the culture of debate that emerged in early Muslim societies created an environment in which science could obtain. Similarly, the religiously sanctioned study of logic allowed thinkers to pursue scientific questions without risking censure.

3.5 Proofs, Rationality, and Heresy

The religious elites' concern that the study of logical methods would lead some to question their authority seems to have been justified. Ibn Hazm (994–1064) suggests that widespread debates and use of logical methods led

some people [to] come to the conclusion that “proofs have equal validity.” This means it is impossible for one [religion] so to triumph over another, or for one [religion] so to vanquish another that truth will shine forth clearly and unmistakably, distinct from error beyond any doubt. Rather, it may be that the proofs from any one [religion] are as valid as those for any of the other [religions]. (Perlmann 1950: 280–21)

It became common to view the study of logical methods and *‘ilm al-kalam* as leading to the belief in “equivalence of proofs” (*takafu al-adilla*) and “skepticism, heresy, and profligacy” (Kraemer 1986: 190).

Although religious leaders initially had incentives to encourage the study of logic, once the majority of the population had converted to Islam,¹⁶ we would expect Muslim religious authorities to rein in their support

for the use of logical methods (unless they continued to use rational methods to bicker among themselves). Inasmuch as the religious authorities' opposition to the study of logical methods was successful, we would expect scientific output to decline as the majority of the population converted to Islam.

3.6 The Decline in Competition and the “Appropriation” of Science

As this conversion occurred, one sect usually was dominant in a given region.¹⁷ The emergence of a Muslim majority occurred at different times across the Muslim world. In Iraq, for example, Islam seems to have emerged as the dominant majority around the eleventh century.

p. 88 Consistent with the previous discussion, at this point the religious authorities began to pressure political leaders to establish *madrasas* or religiously based centers of learning. According to George Makdisi, a prominent scholar of Muslim institutions of learning, the religious authorities created these madrasas to “achieve strength [...] against the forces of rationalism” (Makdisi 1981: 52).

In addition to the difficulties created by the elimination of the institutions where the rational sciences were taught, those who wished to study the sciences faced societal pressures. For example, the Caliph al-Qadir issued an edict between 1017 and 1019 C.E. that “required [r]ationalist religious intellectuals, designated as Mu’tazilis, to make a public retraction, desisting from the public discussion of *kalam*. [...] The guilty had to sign a retraction to this effect and, in case of recidivism, suffer corporal punishment and exile” (Makdisi 1997: 8).

Although some continued to pursue the rational sciences, those individuals had to do so in private behind the facade of another “respectable” occupation. These occupations were within the religious establishment. Indeed, after the emergence of the madrasa, “most astronomical works seem to have been produced by men of religion, and most of them were in fact employed in religious institutions” (Saliba 2007: 243).

Although some have used the fact that these works were produced by religious scholars to argue that there was not a conflict between religion and science in Islam, the intellectual orientation of these scientists and the ultimate fate of the works of these scholars suggests otherwise. Important work done by scientists and thinkers after the emergence of the madrasa does not seem to have been widely circulated or to have affected scientific development in other regions (Sabra 1987; Huff 1993). Scholars have recently argued that the institutional isolation of Muslim scientific activity severely limited the development of Muslim science (Sabra 1987; Huff 1993). Although isolated individuals continued to produce important discoveries, they appear to have generally kept their results to themselves.

Empirical work conducted by Chaney (2008) provides further support for the hypothesis. Data drawn from Ibn Ibn Abi Usayb’ia’s *Sources of News on the Generations of Physicians* detail a drop in the production of the rational sciences approximately when Islam emerged as the dominant majority across the Muslim world.

3.7 Science and Diversity after the “Golden Age”

p. 89 Although this chapter focuses on scientific progress during the Muslim “Golden Age,” the theory developed herein suggests that Muslim religious elites should have ↵ again become interested in promoting the use of logic when Islam extended its borders and incorporated other advanced non-Muslim civilizations.

Preliminary evidence is consistent with the theory. After the Ottomans conquered Christian lands in Anatolia during “the 14th and 15th century madrasas [...] chalk[ed] up distinguished achievements in mathematics, astronomy, and [‘ilm al-kalam]. But by the end of the 16th century this balance had been upset and the rational sciences were severely threatened. There were signs of trouble in the first half of the century [...] with] the declining popularity of mathematics and [‘ilm al-kalam]” (Robinson 1997). These

troubles roughly coincided with the emergence of Islam as the overwhelming majority in the Anatolian peninsula.

Similarly, in the Mughal empire, debates between religions occurred (e.g., those in Akbar's [1542–1605] court). There is evidence that “the rational sciences [...] were not seriously attacked [...] until the 19th century [after the penetration of colonialism]” (Robinson 1997). It is interesting to note that Islam never emerged as the dominant majority in much of the subcontinent.

4. Conclusion

The historical record provides evidence that religious diversity and tolerance helped constrain Islam's conservative elements for hundreds of years. Though religious diversity in premodern Islam was not a sufficient condition for widespread scientific development—many diverse areas remained scientifically underdeveloped—it does appear to have been necessary.

The application of this theory to other religions remains a topic for future research. Although the extent to which the religious authorities derive income and influence from the size of their followings may vary across religions, the “antiauthoritarian” influence of secular education may well be common across faiths. If this is true, we would expect religious authorities of all faiths to resist the introduction of secular studies.

The historical experience of Islam may also hold lessons for those looking to encourage scientific development in the Muslim world today. A recent survey of science by Pakistani scientist Pervez Amirali Hoodbhoy suggests that many parts of the Muslim world remain in what would be described in our framework as a noncompetitive equilibrium. Years of teaching in Muslim regions have led Dr. Hoodbhoy to conclude that ↵

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science can prosper among Muslims once again, but only with a willingness to accept certain basic philosophical and attitudinal changes. [...] The struggle to usher in science will have to go side-by-side with a much wider campaign to elbow out rigid orthodoxy and bring in modern thought, arts, philosophy, democracy and pluralism. (Hoodbhoy 2007: 55)

The historical evidence suggests that opening up the “religious market” to competition in overwhelmingly Muslim countries may encourage conservative religious elites to adopt a less conservative stance vis-à-vis free thinking. The golden age of Muslim science suggests that this less conservative stance will be beneficial for scientific development.

Notes

1. The use of the term *science* is, admittedly, anachronistic. For the purposes of this chapter, “science” will refer to “natural philosophy” or the precursor to modern science. In addition, “Muslim science” refers to scientific work undertaken under Muslim rule, independent of the religious affiliation of the author.
2. See, for example, Huff (1993: 50–51).
3. Or, perhaps more precisely, European development appeared to be Muslim.
4. It is difficult to overestimate how much European technological and scientific development in the Renaissance and Enlightenment periods owe to previous Islamic discoveries. It is widely believed that the translation of the Muslim scientific corpus into European languages in the Middle Ages set the stage for the Renaissance and Enlightenment.
5. For a skeptical view of Saliba's argument, see Huff (2008). Sabra (1987) discusses the decline of Muslim scientific

achievement.

6. These quotes suggest that claims that “it becomes very difficult to document a paradigm of conflict between religion and science in Islamic society” Saliba (1997: 191) are overstated.
7. These religious authorities are best identified with what would eventually be known as the ulama or religious scholars.
8. The “rational sciences” refer to most premodern science. The Islamic sciences referred primarily to the study of religious subjects.
9. Islam had no clergy; instead, it defined orthodoxy through legal schools, which were patronized by the political leaders to obtain legitimacy. Interested readers are referred to Hallaq (2005).
10. Religious tolerance was guaranteed for the “people of the book” (primarily Christians and Jews) by the prophet Mohammed and the Qur’an. Practical constraints on Muslims exercising forceful conversion also existed—after the conquests, Muslims were a small ruling minority among large numbers of other faiths.
11. These interfaith debates seem to have been held relatively frequently and publicly (Stroumsa 1999: 194).
12. For quotes suggesting the effect this had on local opinions and propensities to convert see Griffith (2008: 152) and al-Jahiz (1925: 14–16).
13. In Sunni Islam, sects are best identified with law schools.
14. See, for example, Ghazali’s course of study as outlined in his *Munqidh* (1971).
15. For one such example, see Kraemer (1986: 143).
16. Conversion to Islam was irreversible.
17. The process that led to consolidation of Muslim sects remains poorly understood and a topic for future research.

References

Chaney, Eric. 2008. "Tolerance, Religious Competition and the Rise and Fall of Muslim Science." Mimeo.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Al-Ghazali, Abu Hamid. 1971. *Al-Munqidh min al-Dalal*. Lahore: Hayat al-Awqaf.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Goldziher, Ignaz. 1981 [1916]. "The Attitude of Orthodox Islam toward the 'Ancient Sciences.'" In Merlin L. Swartz, (ed.), *Studies on Islam*. New York: Oxford University Press, 185–215.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Griffith, Sidney. 2008. *The Church in the Shadow of the Mosque*. Princeton, N.J.: Princeton University Press.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Gutas, Dimtri. 1998. *Greek Thought, Arabic Culture: The Graeco-Arabic Translation Movement in Baghdad and Early Abbasid Society*. New York: Routledge.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Hallaq, Wael. 1993. *Ibn Taymiyya against the Greek Logicians*. New York: Oxford University Press.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Hallaq, Wael. 2005. *The Origins and Evolution of Islamic Law*. Cambridge: Cambridge University Press.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Hoodbhoy, Pervez. 2007. "Science and the Islamic World: The Quest for Rapprochement." *Physics Today* 60 (8): 49–55. [10.1063/1.2774098](#)

[WorldCat](#) [Crossref](#)

Huff, Toby. 1993. *The Rise of Early Modern Science*. New York: Cambridge University Press.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Huff, Toby. 2008. "Review of *Islamic Science and the Making of the European Renaissance*." *Middle East Quarterly* 15 (4) (Fall): 77–79.

Al-Jahiz, 'Abu 'Uthman 'Amr Ibn Bahr. 1925 [868]. *Thalath Rasa'il: (1) Fi al-Radd 'ala al-Nasara*. Cairo: al-Matba'a al-Salafiyya.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Khalifa, Hajji. 1835. *Kashf al-Zunun*. London: Richard Bentley.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Al-Kindi, Ya'qub. 1974. *On First Philosophy*. Albany: State University of New York Press.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

p. 92 Kraemer, Joel. 1986. *Humanism in the Renaissance of Islam: The Cultural Revival during the Buyid Age*. Leiden: Brill.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Lewis, Bernard. 2003. *What Went Wrong?* New York: Harper Collins.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Makdisi, George. 1981. *The Rise of Colleges*. Edinburgh: Edinburgh University Press.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Makdisi, George. 1991. *Religion, Law and Learning in Classical Islam*. Brookfield: Variorum.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Makdisi, George. 1997. *Ibn 'Aqil: Religion and Culture in Classical Islam*. Edinburgh: Edinburgh University Press.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Perlmann, Moshe. 1950. "Ibn Hazm on the Equivalence of Proofs." *Jewish Quarterly Review* 40 (3): 279–290. [10.2307/1452852](#)

[WorldCat](#) [Crossref](#)

Renan, Ernest. 2003. *L'Islam et la Science avec la Reponse d'Afghani*. Montpellier: L'Archange Minotaure.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Robinson, Francis. 1997. "Ottomans-Safavids-Mughals: Shared Knowledge and Connective Systems." *Journal of Islamic Studies* 8 (2): 151–184. [10.1093/jis/8.2.151](#)

[WorldCat](#) [Crossref](#)

Sabra, Abdelhamid. 1987. "The Appropriation and Subsequent Naturalization of Greek Science in Medieval Islam: A Preliminary Statement." *History of Science* 25: 223–243.

[WorldCat](#)

Saliba, George. 2007. *Islamic Science and the Making of the European Renaissance*. Cambridge, Mass.: MIT Press.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)

Stroumsa, Sarah. 1999. *Freethinkers of Medieval Islam*. Leiden: Brill.

[Google Scholar](#) [Google Preview](#) [WorldCat](#) [COPAC](#)