

## Epistemological Issues on Science in Contemporary Islam and the History of Arabic/Islamic Science

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### Abstract :

This article looks at the question of the role and relationship of natural philosophy to Arabic-Islamic science, and to what extent it is a factor in the non-emergence of modern science in Islamic civilization. It also discusses the point made by Hossein Nasr that the absence of the Scientific Revolution in Islam is in a sense a blessing because its rejection of Greek natural philosophy—seen to be essential for the rise of modern science—implied the preservation of Islamic metaphysics. The article continues by discussing the counter-factual question of whether it would have been better for Islamic science to go the way of Western science, or that what had historically happened was indeed the best choice for Islamic civilization. The article ends by looking at the relevance of the above issue to the contemporary practice of science in Islam, especially with respect to epistemology.

### ملخص :

ينظر هذا المقال في مسألة دور وعلاقة فلسفة الطبيعة بالعلم العربي الإسلامي والعوامل التي تفسر عدم انبجاس العلم الحديث في الحضارة الإسلامية. ويقوم أيضا بمناقشة الرأي الذي عبر عنه حسين نصر والذي مفاده أن غياب الثورة العلمية في الإسلام هو من قبيل البركة لأن رفضه لفلسفة الطبيعة اليونانية - التي كان ينظر إليها على أنها أساسية في ظهور العلم الحديث - ينجر عنه الإبقاء على الميتافيزيقا الإسلامية. ويواصل المقال مناقشة المسألة المتمثلة في تحديد ما إذا كان من الأجدر على العلم الإسلامي أن ينحو منحى العلم الغربي أم هل أن ما حدث في التاريخ كان في الحقيقة الخيار الأفضل للحضارة الإسلامية. ومخلص المقال إلى تناول هذه المسائل في علاقتها بالممارسة المعاصرة للعلم في الإسلام وخاصة بالنظر إلى الاستيمولوجيا.

### Résumé :

Cet article porte sur la question du rôle et de la relation de la philosophie naturelle à la science arabo-islamique et sur les facteurs de la non-émergence de la science moderne au sein de la civilisation islamique. On y discute aussi le point évoqué par Hossein Nasr selon lequel l'absence de révolution scientifique en Islam était un fait bénéfique, car le fait que l'Islam rejette la philosophie naturelle grecque - considérée comme essentielle pour la genèse de la science moderne - implique la préservation de la Métaphysique islamique. L'article poursuit sur la discussion de la question de savoir s'il était mieux pour la science islamique de marcher sur les traces de la science occidentale, ou bien doit-on considérer que ce qui s'est passé historiquement était le meilleur choix pour la civilisation islamique. L'article se termine sur un examen de toutes ces questions par rapport à l'enjeu de la pratique contemporaine de la science en Islam surtout par rapport à l'Epistémologie.

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## 1.0 Introduction

The history of Arabic science serves as an important phenomenon to be studied, from which important epistemological lessons can be drawn. Some of the questions posed in the study of the history of Arabic science, are: (i) what were the factors that led to the rise and decline of Arabic science (ii) what was the role of religion and philosophy in the development of Arabic science? (iii) Was Arabic science realist or instrumentalist? Although not all of these concerns were epistemological, some were. In this paper we will focus on certain epistemological issue relating to Arabic science.

In this paper I would like to pursue the issue raised by Hossein Nasr concerning the supposed ‘failure’ of Arabic science to give rise to modern science through the Scientific Revolution, and his seeming approval of the ‘failure’. In what sense is it a failure, and in what sense is it not? I maintain that Arabic science was only a ‘failure’ when judged against the standards of modern science and the Scientific Revolution, in the sense that it did not transform itself to modern science. However, this so-called ‘failure’ has a positive aspect in that it preserved ‘Islamic metaphysics’ and the enchanted character of Arabic/Islamic science.

A related issue dealt with in this paper is the paradox involved in the historical explanation of Arabic science. While historians have lauded the success of Arabic science especially from the 9th to 12th centuries, they have also criticized its ‘decline’ and ‘stagnation’ beginning from about the 14th century. However, the same or almost similar, set of factors was present in both cases, which paradoxically led to success in the earlier period and ‘failure’ in the later period. The second part of this paper will therefore focus on that question, and attempt to resolve the paradox.

Finally, I will conclude by arguing that the so-called ‘failure’ of Arabic science is only in a relative sense, and that it cannot be blamed for its lack of cultivation of natural philosophy since: (i) the role of natural philosophy in the further development of science can only be known through hindsight, and (ii) it was able to avoid an epistemological-cultural crisis as a result of its attitude towards natural philosophy and scientific realism.

## 2.0 Natural Philosophy and Science in Islamic Civilisation

The lack of the cultivation of natural philosophy in medieval Islamic civilisation has been identified as a major reason for the inability of Islamic Science to develop further after reaching its golden age (Grant 2004; Cohen 2010). Among others, those who have subscribed to this thesis in some form or other are; Edward Grant (2004, 2007), Toby Huff (1995), Floris Cohen (2010), and Von Grunebaum (Lindberg 1992). Even Nasr (1996, 1997) accepts this thesis in a way, although unlike the rest, he does not see it as a defect, but as a blessing since Islamic Science remained enchanted and infused with an enchanted (Islamic/Mystical) metaphysics. This thesis deserves further attention, and examination, and elaboration, and in order to avoid the charge of it being a simplistic explanation of the stagnation and decline of Islamic science. In order to pursue this thesis further, we have to consider the following:

Firstly, we have to ascertain whether it is true that there is an absence or lack of natural philosophy in Islamic science or in Islamic culture in general. Some, much as Ahmad Dallal (2010) have pointed out to the existence of natural philosophy in Islamic astronomy. Was *Kalam* (as opposed to *Falsafa*) not a form of natural philosophy in some sense? Or was *Kalam*, by virtue of its opposition to *Falsafa*, not able to give rise to a class of theologian-natural philosophers, unlike in Christian Europe? (Grant 2004). In any case, natural philosophy did not seem to hold out any hope or promise for the further development of science as seen from the points of view of a 14th century scholar for instance, which is perhaps why Ibn Khaldun writing in the 14th century did not see it as knowledge worthy of pursuit (Grant 1996: 181). In fact it is only with hindsight that we are able to see the contribution of natural philosophy to the development of science after the 17th century. Even then, the marriage of natural philosophy, mathematics and the experimental method did not really bear empirical fruit until as late as the 18th or 19th century with the atomic theory in chemistry and physics.

Secondly, assuming that there is a lack, or even absence, of natural philosophy in Islamic science, how do we explain its necessity for the further growth of science? One way of finding out is to compare the role played by natural philosophy in the rise of modern science in the West. An explanation of how natural philosophy played its role in the theoretical development of science in Europe could throw light on why a similar development did not take place in the Islamic world. The significance of natural philosophy perhaps lie in its contribution to theoretical development of the natural sciences, since it is the development of theory (in the form of natural philosophy) in western science, which when combined with mathematics and experimentation, led to the birth and growth of modern science in Europe (Henry 2008; Cohen 2010).

Thirdly, what were the cultural, religious, or metaphysical factors that prevented the development of natural philosophy, and a 'materialist metaphysics in Islam? And how was Europe able to 'Christianise' an alien or even atheistic metaphysics such as Atomism, into its science? What was Boyle's and Gassendi's role in this transformation? Here, Nasr's thesis on the refusal of Islamic science to adopt an alien metaphysics contrary to the spirit and world-view of Islam is certainly relevant in explaining why further theoretical development did not take place in Islamic science.

Fourthly, there is a need to understand the rise of the Faustian spirit in the West, as exemplified by Bacon's philosophy of man achieving dominion over Nature, and legitimized through Christian mythology. It was Bacon's identification of Truth with Practice, of Knowledge with Power that led to the acceptance of a metaphysics such as the one implicit in the mechanical philosophy, in the Western world despite its materialist and atheistic overtones. In Bacon's philosophy, successful Practice is a sign of Truth and that natural science should aim not only at contemplative understanding - which was typical of the Greeks and Medievals - but more importantly, at successful manipulation of the world. Given this philosophy and ethic, it is no surprise that experimental and practical success became the criteria for Truth (Gaukroger 2006), legitimizing the acceptance of any ontology or metaphysics that could bear empirical fruit. This alliance

of Truth with Practice in western science, and the philosophy of scientific realism which consequently followed, was criticized by Peter Dear (2005) in his article 'On the early Modern Roots of the Ideology of Modern Science', where he viewed this as an ideology of modern science.

The identification of theory and practice in Islamic science, although it did occur to some extent, was somewhat constrained by Islamic metaphysics and value-system, which rejects a Faustian attitude towards nature or the acceptance of a materialist metaphysics. In Islam, the attitude adopted towards Nature was one of Reverence towards God's Creation, and of Man's role as Vicegerent or Guardian of God's property, rather than its master. Practice in Islamic science was more utilitarian, and non-realist (Sabra 1987). Practical efficacy was not held as a proof or criterion of ontological truth. In astronomy for instance, astronomy served as a handmaiden to religion by providing practical services such as the determination of the direction of the Qibla in Mecca, and the determination of the prayer times, and fasting month.

In the West, the cultural consequences of such a fusion of theory and practice was deeply acknowledged by the philosopher-sociologist, Ernest Gellner. In his *Legitimation of Belief* (1974:196-198), Gellner dwelt on that point in some detail. For Gellner, modern science has robbed us of our simple faith in the 'ordinary world', such that the observable world around us accessed through our sense organs no longer hold the certain truth that it once held. Instead, it is science—or rather Physics—which is capable of telling us the deep truths about our natural world, of which our observable world is only the surface or end-surface of that deep structure revealed through Physics. To quote Gellner (1974: 197-98):

It is precisely because the new science speaks in a strange and 'technical' idiom, referring to a cold and inhuman world, which is discontinuous with the notions of everyday life, and because at the same time the new science manifestly has much greater cognitive power than any contained in the practices of everyday life, that daily life has come to be surrounded, as part of its very nature, as part of that which is 'lived', by tacit, doubt-conveying quotation marks. We are not too sure of the status of anything within this ordinary world. Real knowledge, science, may re-validate it—or not. In the meantime, we continue to live in the ordinary world and use its ordinary concepts, for generally speaking we have no choice and no alternative, but we do it with a certain amount of distrust. It has a kind of interim status.

Gellner's statement is an eloquent expression of the epistemological dilemma of western intellectuals caught between the two realities: the one offered by common-sense and the ordinary everyday world, and the other offered by science. But that dilemma I suggest, only arose as a consequence of the emergence of the new science, when theoretical truth was subject to empirical-experimental confirmation. By connecting the two, theoretical reality obtained the support of the observable world, which paradoxically turned against that ordinary observable world itself. Arabic/Islamic science was spared of this epistemological crisis or dilemma because it did not fuse theory with practice, and hence also did not create modern science. It was able to maintain its own metaphysical view of

the world because it did not subject ontology and metaphysics to methodology. The West took that ominous step of consuming ‘the forbidden fruit of knowledge’; knowledge which in Bacon’s conception should not only lead to intellectual understanding but also bear practical fruits.

### **3.0 The Rise and Decline of Arabic Science: The Problem of Explanation**

One problem faced in trying to explain the rise or decline of Arabic Science is the fact that the same set of factors - or a number of them- is present in both situations. While we acknowledge the success of Arabic science especially from the 9th to 12th centuries, we lament its so-called ‘decline’ after the 12th century. But the ‘character’ of Arabic science has not substantially changed during that period, i.e. from the 9th to 14th centuries, so how come that the same (or roughly same) set of factors that were present during its rise, is now blamed for its decline? For example, it is well-known that natural philosophy, especially Greek natural philosophy, was not well-received especially after Al-Ghazali’s critique in the 11th century (Grant 2004:237-238). Yet Islamic science continued to make progress after the 11th century.

However, one of the reasons offered for the decline of Arabic Science was the lack or absence of natural philosophy (Grant 2004). Although there is some truth to the hypothesis, I think it needs to be explained in some details, so as to avoid any misperception. Now it should be borne in mind that such a view of Arabic science can only be made through hindsight, and relative to the rise of modern science in Europe through the Scientific Revolution of the 17th century. The role of natural philosophy in the rise of modern science in 17th Century Europe is now almost indisputable as has been shown by scholars such as Floris Cohen (2010), Edward Grant (2007), and Stephen Gaukroger (2006). However, this role has to be clearly understood, so that we will not make the wrong inferences regarding Arabic science. Now the role of natural philosophy in this case, is achieved through its ability to be integrated with mathematics and the experimental method, and not by ‘standing alone’. In other words, even if Greek natural philosophy had been cultivated in the Islamic world, it would not have automatically led to the advancement of Arabic Science. In fact, before the 17th century, such approaches in the history of science involving the separation of theory from practice, was quite normal and was indeed the norm. Arabic science even flourished within such a context of separation. So when we talk about the ‘decline’ of Arabic Science, it is really against the background of 17th century science in Europe, which was indeed revolutionary. Thus there was really nothing ‘seriously wrong’ with Arabic Science as such, only that it did not take that next revolutionary step which (as Europe had shown) was what was needed for its further advancement. Natural philosophy provided the theoretical resources for a science like Physics to expand further through the development of the atomic theory. The separation of the Athenian and Alexandrian approaches means that they could only advance so far. In fact it could be said that in Islamic science, the Alexandrian approach has reached its limits. In the light of the above explanation, we can now understand why the same set of factors that was responsible for the rise of Arabic Science is now also the reason for its decline.

#### 4.0 The Nasr Thesis and the Non-Emergence of Modern Science in Islamic Civilisation

What is the ‘Nasr thesis’? Although Nasr did not explicitly state his ideas in the form of ‘thesis’, the view, which he presented can be stated as such. Basically, the Nasr thesis’ refers to the non-emergence of the Scientific Revolution in Islamic Civilisation, or the non- transformation of Arabic science to modern science, and Nasr’s ‘positive’ evaluation of such a non- transformation because of its preservation of Islamic metaphysics. According to Nasr (1997:97-98):

In fact it might be said that the main reason why modern science never arose in China or Islam is precisely because of the presence of metaphysical doctrine and a traditional religious structure, which refused to make a profane thing of nature. Neither the ‘Oriental bureaucratism’ of Needham nor any other social and economic explanation suffices to explain why the scientific revolution as seen in the West did not develop elsewhere. The most basic reason is that neither in Islam, nor India nor the Far East was the substance and stuff of nature so depleted of a sacramental and spiritual character, nor was the intellectual dimension of these traditions so enfeebled as to enable a purely secular science of nature and a secular philosophy to develop outside the matrix of the traditional intellectual orthodoxy. Islam, which resembles Christianity in so many ways; is a perfect example of this truth, and the fact that modern science did not develop in its bosom is not the sign of decadence as some have claimed but of the refusal of Islam to consider any form of knowledge as purely secular and divorced from what it considers as the ultimate goal of human existence.

Now, why did Nasr come up with such a judgment, while others such as Toby Huff (1993) or Pervez Hoodbhoy (1972), see it as a ‘failure’? The differing judgments on the historical phenomenon mentioned are due mainly to the differences in their perception and attitude towards modern science, in relation to religion. While Nasr, who claims himself to be a ‘Traditionalist’, sees modern science as espousing a philosophy and epistemology which diverges from the true religious or Islamic spirit, modernists such as Hoodbhoy and Huff adopted the Enlightenment view of science as essentially liberating. As a consequence, Hoodbhoy and Huff saw the Scientific Revolution in positive terms—as something which is to be emulated or aimed at—while Nasr viewed it as a form of ‘metaphysical regression’.

#### 5.0 Epistemological Issues on Science in Contemporary Islam

While the West has been plagued by epistemological problems concerning science, such as the issue of Scientific realism, the Islamic world, precisely because it did not develop modern science, was not subjected to such ‘epistemological crisis. With the integration of natural philosophy, mathematics and the experimental method in Western or modern science there arose the issue or question of whether the entities, and/or mechanisms postulated by the scientific theory (i.e. its natural philosophy component) is real. There also arose the question of the nature of that ultimate physical reality, and whether only science can reveal that knowledge to us. This issue can rightly said to have reached ‘crisis

proportions' through the so-called 'Eddington problem' which posed the question of why our every day experience of objects conflict with the physical picture of the world as given by science, especially Physics (Gellner 1974:196). Belief in the authority of science in delivering such knowledge has sometimes been labeled as 'scientism'. And might even imply a type of 'scientific' or 'materialistic reductionism'.

Because such an integration of natural philosophy, mathematics and the experimental method did not occur in Islam science, the epistemological problem of scientific realism therefore did not occur in Islam, and that it was spared any form of scientific materialism or reductionism. It was also possible to retain the metaphysical view of the world based on Islamic metaphysics and philosophy, holding secularism at arm's length. But although Arabic/ Islamic science saved its soul or the soul of the Muslim scientific through the non-integration of natural philosophy with mathematics and the experimental method, it conceded scientific leadership to the West, which made that more and bought the development of science to a new level which saw the emergence of modern science.

Through colonization and globalization the modern science of the West was later transferred to the Islamic world, and the epistemological crisis, which had earlier beset the West, now dawned upon the Islamic world as well. But the Islamic world was slow to perceive it as a problem, and only a few of its intellectuals such as Hossein Nasr, saw it as an epistemological problem, whose solution lies in the adoption of Islamic metaphysics in looking at science, and in motions such as the 'Islamisation of science'. Others, especially practicing scientists, and government officials & bureaucrats, in their desire to adopt science and technology for national development and modernization, ignored the epistemological dimension and instead only focused on its positive contribution to modernization, economic growth, and national development.

Thus the reason why issues such as 'scientific realism' is so hotly debated in the West but not in contemporary Islam, is not so much because such as epistemological problem does not exist, but that its awareness among Muslim intellectuals is lacking. Also because of the lack of secularization in the Muslim world, it still remains respectable for the Muslim intellectual-qua believer- to adopt an Islamic perspective towards knowledge, including scientific knowledge, without losing his intellectual credibility among fellow Muslim. This is unlike the situation in the West, when it is not really an option to adopt a 'Christian Perspective' towards science, in dealing with epistemological issues such as the problem of scientific realism.

But given that modern-day Muslims do not want to shun modern science and technology, while yet remaining Muslims, it thus became imperative upon the Muslim mind to squarely face the issue from an Islamic perspective. Here, although the intellectual resources are there, they are rather limited by the fact that the contemporary Muslim cannot really draw from history science. Science as it existed in Medieval Islam is different in character from modern science. The epistemological situation facing him is novel in character, and that novelty requires an equally new and fresh approach in dealing with the issue. One consolation—if it can be conceived as such—is the existence of

attempts by contemporary Western thinkers on the issue, which Muslim thinkers can draw upon. Even contemporary Muslim thinkers such as Ziauddin Sardar and Hossein Nasr have drawn upon some of the arguments made by contemporary Western thinker on science, in their critique of science and its Islamic alternative. The further challenge however, is for the Muslim thinker to not merely imitate the arguments of the West without injecting an authentic Islamic element in developing his view of science.

## 6.0 Conclusion

While Western philosophy of science was grappling with the issue of scientific realism, the Muslim intellectual world was almost oblivious to it, choosing instead to focus on ‘The Islamisation of knowledge’ or the ‘Islamisation of science’, which would serve as a

panacea to all epistemological problems relating to science and Islam. Why was this the case? My hypothesis is that the Muslim intellectual world, unlike the Western intellectual world, did not have to face the problem of scientific realism because the Athenian tradition was not fused with the Alexandrian tradition in the development of Islamic science. As a result, natural philosophy was not subjected to ‘tests of reality’ through the experimental method. In the West, because of the integration of natural philosophy, mathematics and the experimental method, the question of the ‘reality of the world’ as described through natural philosophy became a real issue, especially since theory-testing through experimentation, gave the impression that the shape of physical reality as presented through the ‘natural philosophy’ component, can be put to an empirical test through experimentation. This idea that the support given by experimental proof or evidence is support for the “ontology” of the theory, i.e. its natural philosophy component, became the gist, crux or pillar of scientific realism. Later on however, through the efforts of anti-realist philosophers, it was realized that the connection between experimental proof/evidence and ontological truth of the theory, is not automatic and can be contested. The cultural implication of the position adopted with regard to scientific realism is enormous since it amounts to the cultural- epistemological privileging of science, or otherwise. The realist position would have given cultural legitimation to science in a metaphysical/ontological sense, while the anti-realist position would not, even though it does not necessarily ‘de-privilege’ science.

Now in the Islamic world, such epistemological controversies concerning scientific realism did not occur, even though by right it should have affected Islamic thought itself, when science became transplanted or imported into the Muslim world through colonization and globalisation. Going back to the historical development of Islamic science in the Middle Ages, we can again pose the question of whether it was really a blessing - as Nasr (*Man & Nature* 1997, p. 98) would have it- that Islamic science did not go the way of Western science, and was able to save its own metaphysical view of the world. Would it not have been better, counterfactually speaking, if Islamic science had been able to combine natural philosophy— even if it is in the form of Islamic metaphysics – with mathematics and the experimental method? My answer is: had this happen, then Islamic science would not have been able to retain its character, i.e. Islamic science would

no longer remain 'Islamic'. This is because the combination would make metaphysics subordinate to methodology, because in the end theory-acceptance is decided through experimental confirmation. Thus Islamic metaphysics could be either confirmed or disconfirmed by empirical-experimental tests. In other words, it could be rejected and replaced by a different metaphysics which are in agreement with the empirical data but does not form part of the Islamic world-view. This 'secularisation' of Islamic science would not have been possible in a non-secular Islamic world, where metaphysics reign supreme. Obviously, there is a price to be paid for it, and the price is the lack or absence of further theoretical and empirical progress in Islamic science. Islamic science had historically reached the limits of its own potentiality, and re-inventing itself through secularisation was not an option. Had Islamic science gone the way of Western science (assuming that it was possible), it would have faced the problem of scientific realism and other epistemological issues connected with modern science in its Western cultural context.

## REFERENCES

- Anstey, Peter R. and John A. Schuster. 2005. *The Science of Nature in the Seventeenth Century: Patterns of Change in Early Modern Natural Philosophy*. Dordrecht: Springer.
- Blair, Ann. 2006. Natural Philosophy. In Katharine Park and Lorraine Daston (eds.), *The Cambridge History of Science. Volume 3: Early Modern Science*. Cambridge: Cambridge University Press, pp. 365-406.
- Cohen, H. Floris. 2005. The Onset of the Scientific Revolution: Three Near-Simultaneous Transformations. In Peter R. Anstey and John A. Schuster (eds.), *The Science of Nature in the Seventeenth Century: Patterns of Change in Early Modern Natural Philosophy*. Dordrecht: Springer, pp. 9-33.
- \_\_\_\_\_. 2010. *How Modern Science Came Into the World*. Amsterdam: Amsterdam University Press.
- Cunningham, Andrew and Perry Williams. 1993. De-Centering the 'Big Picture': "The Origins of Modern Science" and the Modern Origins of Science. *The British Journal for the History of Science*, Vol. 26, No. 4, 407-432.
- Dallal, Ahmad. 2010. *Islam, Science, and the Challenge of History*. New Haven & London: Yale University Press.
- Dear, Peter. 2005. What Is the History of Science the History Of? Early Modern Roots of the Ideology of Modern Science. *Isis*, 2005, 96:390–406.
- Gaukroger, Stephen. 2006. *The Emergence of a Scientific Culture*. Cambridge: Cambridge University Press.
- Gellner, Ernest. 1974. *The Legitimation of Belief*. Cambridge: Cambridge University Press.
- Grant, Edward. 1996. *The Foundations of Modern Science in the Middle Ages*. Cambridge: Cambridge University Press.
- \_\_\_\_\_. 2004. *Science and Religion*. Baltimore: Johns Hopkins University Press.
- \_\_\_\_\_. 2007. *A History of Natural Philosophy: From the Ancient World to the Nineteenth Century*. Cambridge: Cambridge University Press.
- Henry, John. 2008. *The Scientific Revolution and the Origins of Modern Science*. Basingstoke, Hampshire: Palgrave MacMillan.

Hogendijk, Jan P. and Abdelhamid I. Sabra. 2003. *The Enterprise of Science in Islam: New Perspectives*. Cambridge, Massachusetts: The MIT Press.

Nasr, Seyyed Hossein. 1996. *Religion and the Order of Nature*. Oxford: Oxford University Press.

\_\_\_\_\_. 1997. *Man and Nature: The Spiritual Crisis in Modern Man*. Chicago: ABC International.

\_\_\_\_\_. 1998. Islamic Science, Western Science: Common Heritage, Diverse Destinies. In Ziaudin Sardar (eds). *The Revenge of Athena Science, Exploitation and the Third World*. London and New York: Mansell Publishing Limited.

Sabra, A. I. 1987. The Appropriation and Subsequent Naturalization of Greek Science in Medieval Islam: A Preliminary Statement. *History of Science* 25 (69):223-243.