CONTEXTS AND CONSTRUCTIONS OF OTTOMAN SCIENCE WITH SPECIAL REFERENCE TO ASTRONOMY

by

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CONTEXTS AND CONSTRUCTIONS OF OTTOMAN SCIENCE
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ABSTRACT

The two approaches that restrict, and perhaps even hinder, the study of the history of science in the Ottoman context are as follows:

1) Ottoman Science is expected to be progressive and even modern;
2) Ottoman Science is considered a continuation of Arabic science.

This thesis claims that both approaches are unlikely to bear any fruit, or to display the more pertinent and interesting aspects of Ottoman science. The first approach restricts the study of the history of science in the Ottoman context because Ottoman science shows little progress across the centuries; because much of that progress has been borrowed, transferred or appropriated, from modern Europe, and because "progress" itself, beyond perfecting and correcting prevalent scientific theories, does not seem to be an ideal of science as practised in the Ottoman Empire; and because early modern science itself was not unambiguously progressive. The second approach is restrictive because it overlooks the fact that the majority of Greek and Arabic science was incorporated into both European and Ottoman learning, and the Ottomans for the most part, were not exclusive heirs to Arab learning. Moreover, when one speaks of the Ottomans, one does not necessarily speak of Turks and Arabs, but also of Greeks, Jews, South-east Europeans, emigrés from very different ethnic and religious backgrounds as well as many others. The first chapter will try to define *ʿilm*, the Arabic word most Ottomans who spoke Turkish or Arabic used to connote learning and science, and distinguish it from modern science as we know it today. The second chapter will treat Greek learning before and during Ottoman domination and will try to highlight the role Ottoman Greeks have played in the Ottoman intellectual and scientific scene. The third and fourth chapters will evaluate from a comparative perspective the history of Ottoman and European astronomy in early modernity. This chapter seeks to show the similarities between the study of astronomy in the two scientific ecumenes. The fifth and last chapter is a critical overview of the the historiography of Ottoman Science.

ASTRONOMİYE ÖZEL ATIFLA OSMANLI BİLİMİNİN
BAĞLAM VE YORUMLARI
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ÖZET

Osmanlı bağlamında bilim tarihinin çalışılmasını kısıtlayan, ve belki de engelleyen, iki yaklaşım şöyledir:

1) Osmanlı Bilimi'nin ilerlemesi ve hatta modern olması beklenmektedir;
2) Osmanlı Bilimi, Arap Bilimi'nin devamı sayılmaktadır.

Bu tez, iki yaklaşımın da meyve vermesinin, veya Osmanlı'da bilimin belirleyici ve ilginç kısımlarını öne çıkarmasının olası olmadığının bir savunmasıdır. Birinci yaklaşım Osmanlı bağlamında bilim tarihinin çalışılmasını sınırlar, çünkü Osmanlı'da bilim, yüzyıllar boyunca pek az gelişim gösterir; çünkü Osmanlı'da bilimsel ilerlemelerin büyük çoğunluğu modern Avrupa'dan ithal edilmiştir; çünkü Osmanlı'da, varolan bilimsel teorileri düzeltmenin ve mükemmelleştirmenin ötesinde "ilerleme" bir ideal olarak öne çıkmaz; ve çünkü erken modern Avrupa da bilim alanında belirgin şekilde ilerici değildir. İkinci yaklaşım sınırlayıcıdır, çünkü Yunan ve Arap Bilimi hem Avrupa'de hem de Osmanlı'da icra edildiği şekliyle bilimin bir parçasıdır: Osmanlı, Arap Bilimi'nin ayrıcalıklı mirasçısı değildir. Ayrıca, Osmanlılar'dan bahsedildiğinde sadece Türkler ve Araplar'dan değil, Rumlardan, Musevilerden, Güneydoğu Avrupalılardan, pek çok farklı geçmişten gelen mültecilerden ve diğer pek çoklarından bahsedilmektedir. Birinci bölüm 'ilmin, yani pek çok Arap ve Türk'ün erken modern dönemde öğrenim ve bilim anlamında kullandığı kelimenin tanımlanmasıyla, ve bugünkü bildiğimiz şekliyle modern bilimden ayırt edilmesiyle ilgilidir. İkinci bölüm Osmanlı idaresinden önce ve bu idare altında Yunan bilgi ve bilimi değerlendirmesidir; ve Rumların Osmanlı entelektüel ve bilimsel hayatındaki rolünü vurgular. Üçüncü ve dördüncü bölümler erken modern dönemde Osmanlı ve Avrupa astronomisinin karşılaştırmalı (İkisinin farklılıklarından çok benzerliklerine odaklı olarak) bir incelemesidir. Beşinci ve son bölüm Osmanlı bilim tarihyazımının bir eleştirisidir.

Note on Transliteration

Modern Turkish transliterations of Ottoman Turkish words have been used throughout this thesis. Long vowels and the letter " 'ayn" (ع) have been shown in this transliteration, but the diacritics have not been employed for the consonants. The names of writers of Arabic origin and their works have been written in latinized Arabic, and the transliteration used in the respective secondary sources has been employed.

Abbreviations

EI^2: Encyclopedia of Islam, 2nd edition
Cop. Rev.: Kuhn, Thomas S. *The Copernican Revolution*. HUP: Cambridge, MA. 1985 [1957]
Osm. Ast.: İhsanoğlu, Ekmeleddin et al. *Osmanlı Astronomi Literatürü Tarihi.* İstanbul: IRCICA, 1997.
Obs. Isl.: Sayılı, Aydın. *The Observatory in Islam.* Ankara : Atatürk Supreme Council for Culture, Languange and History Publications of the Turkish Historical Society, 1988.

Babama,

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CONTEXTS AND CONSTRUCTIONS OF OTTOMAN SCIENCE

WITH SPECIAL REFERENCE TO ASTRONOMY

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CONTEXTS AND CONSTRUCTIONS OF OTTOMAN SCIENCE

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1. INTRODUCTION: *ʿİLM* AND SCIENCE

1. 1. What *ʿilm* is not

The history of Ottoman science is mostly the history of *ʿilm*. The history of science proper, a history that sets out to discover scientific progress and contribution to the science of today[1] should not be forced upon this history. The history of Ottoman science cannot be separated from its context of disciplinary divisions and practices. Although tradition has played a significant role in the formation of Ottoman science, tradition in itself does not connote backwardness, if advance or backwardness at all is a useful parameter for the contextualized study of science.[2] Moreover, not all who practiced, learnt, or taught science in the Ottoman Empire and in Europe belonged to the same tradition, although the approaches of many were determined by some kind of tradition, modern science being one among them. This thesis sets out to show that while modern science has been able to uproot Aristotelian learning in early modernity, the process has been complex, and progress has not been without retrogression. Ottoman science, when studied in comparison with a fine-grained history of European science seems to tie in with some of the intellectual trends in early modern Europe, but often cannot be associated with modern science as we know it today. First and foremost, keeping in sight even the Scientific Revolution, a term in the formation of which Alexandre Koyré played a decisive role. The word "scientist" was coined in Europe by Whewell and not before the 19th century, and only then was the business of someone dealing with modern science clearly distinguished from that of the natural philosopher. The term "natural sciences" covers a range of disciplines

[1] See "Turkish Contributions to Scientific Work in Islam" in *Belleten* XLIII/172. 1979, (see esp. pp.736-7), and "George Sarton and the History of Science" in *Belleten* XLVII/186. 1983. (see esp. p.502) by Aydın Sayılı, who was a student of George Sarton. Also see A.Adıvar *Osmanlı Türklerinde İlim 6th ed.* ed. A.Kazancıgil and S.Tekeli. Istanbul: Remzi, 2000[1943] for this notion of the history of science.

[2] A good study that contextualizes the history of science is S.Shapin's *The Scientific Revolution*. Chicago: UCP,1996.

from physics, to biology, to chemistry, to zoology to astronomy. Natural philosophy, i.e., speculative, not applied, philosophy dealing with natural phenomena, covered a similar area, but it was chiefly theoretical. The Arabic Natural Philosophical tradition was no exception to this. In fact, that natural philosophy was a branch of speculative philosophy was set forth by Aristotle long before the rise of either European or Arabic science.

In order to understand the content and the context of Ottoman science, one should study the worldviews of its students and practitioners. The worldview would give us an idea about what knowledge was, what was considered knowable, or worth being known. In the process of describing these worldviews, one should also keep in mind that modern science also has in its entourage a worldview of its own, if not many of them. Competing and opposing worldviews will show hostility towards or disregard for each other in varying degrees. Early modernity, a period extending from the Renaissance to the French Revolution, was characterized by such competing worldviews, and science, or rather natural philosophy, was one of the areas of competition. One cannot say with unflinching certainty that any worldview pursued truth more vehemently than another, since clear and cogent arguments have been made for all of them. One should only expect that Ottoman Empire would be a party in these debates.

In the case of astronomy, the central debate was, or at any rate is now thought to be, whether the earth was at the center of the universe. One finds that the many Ottoman astronomers, like some of their European counterparts, opted for the geocentric system and made light of the heliocentric system. By 1730, Müteferrika had already published a clear exposition of the Copernican system, although he had favored the geocentric system in his treatment; but that had not led to a great disturbance among the educated. Ottoman astronomy, and for the most part, European astronomy as well, had two main branches, *ʿilm-i zîcet*, observational/computational astronomy, and *ʿilm-i hey'et*, theoretical/geometrical cosmography. Copernicus had addressed himself to the latter group, but the reverberations of his theory would reach much farther. Natural philosophy, *ʿilm-i tabiʿiyye*, which studied the nature of motion and matter, was a quite different field, but one that nevertheless related to astronomy, and

Copernican astronomy would be out of place in this larger context of natural philosophy before natural laws of motion were discovered in the latter half of the 17th century by Galileo, Kepler and Newton. The heliocentric model of the universe became a viable alternative, and in a much different form than the original Copernican model, to the Ptolemaic/Aristotelian cosmos long after 1543 when Copernicus published his monumental work, *De Revolutionibus.*

The uses of astronomy were quite another matter. Modern science was not any more of a purer search for truth than Aristotelianism.[3] Aristotelian astronomy had in mind the chain of causes leading to the final cause in its pursuit of truth, while modern astronomy concerned itself with efficient and immediate causes and patterns based thereupon. It also had its own agenda, advancement of the kingdom of man. In the modern framework, the uses of astronomy had also changed. Astronomy started to serve geography more than anything else. Previously, astronomy was useful for four chief purposes: Timekeeping, calendar preparation, navigation and astrology. Timekeeping and calendar preparation made use of the motions of the sun and the moon in relation to the earth, and could benefit little from the heliocentric system as such. Even in our day, navigation assumes a geocentric and geostatic universe. Astrology was underpinned by a natural philosophy that assumed a simple and sublime supralunar realm which influenced the sublunar world. Astronomy had occupied an important place in the daily lives of many. Today, astronomy has become of auxiliary importance. Before physics and astronomy merged in the writings of Galileo and Newton, the undoubted guidance of the stars was followed by navigators and astrologers. After Newton, such uses and practices slowly had to place themselves not on a basis of truth, but of hypothesis.

My initial intent in writing this thesis was to delve straight into the natural sciences in the Ottoman Empire. I had come in with a markedly modern question, i.e. that I would be dealing with the positive natural sciences that we are acquainted with today, especially physics, astronomy and the various branches of engineering. However, as I went along, I realized that all these disciplines, now ruling over defined

[3] Shapin, pp.119-20

areas of competence and generally ruled over by *the* scientific method, are not applicable tools of analysis in the study of medieval and early modern science.

The distinctions we believe exist between science and pseudo-science were not so firmly established then, at least not in a manner palatable to the distinctly modern tastes we all represent to some degree. For example, Newtonian physics, now considered the standard bearer of the modern discipline, ran into many troubles and was even deemed by some an obscure excursion into the secrets of nature via an unsure mathematical method. Berkeley, in his *Analyst*, blamed Newton for the notions and concepts of calculus he employed in the *Principia*. He was even accused of esoteric calculus terminology, ridiculed as "incipient celerity of an incipient celerity, nascent augment of a nascent augment" by Berkeley.[4] True, calculus was a truly new brand of mathematics and had introduced motion into a field that stood as the epitome of motionless and perfect truths of the unaided human mind. Yet, calculus in time became the normal language of the science and has been serving as a tool to the advance of all physical sciences.[5]

Newton himself questioned whether natural philosophy as it had been practiced since antiquity was getting people anywhere. A field ridden with disputes and wanting in conclusive answers to anything whatsoever was consuming the efforts of schoolmen and was furthermore monopolizing an otherwise promising field, which Newton defined as mathematical physics in the *Principia*. Natural philosophy, a field that dealt mostly with the structure of the universe, the meaning and the source of motion, etc. was far too cosmological to really engage in the detail work involved in explaining phenomena. Of course, the notion of explanation itself was modified then, partly through the efforts of Galileo. The ancient and the medieval traditions of natural philosophy inquired into the causes, leading up the final cause, featured a line of reasoning that led from the most immediate cause to God, and dealt with the ideal

[4] G. Berkeley. *The Analyst: A Discourse Addressed to an Infidel Mathematician.* (http://www.maths.tcd.ie/pub/HistMath/People/Berkeley/Analyst/Analyst.pdf.) ed. D.R. Wilkins.Trinity College. Dublin, Ireland. 2002.

[5] See E. Wigner. "The Unreasonable Effectiveness of Mathematics in the Natural Sciences," in *Communications in Pure and Applied Mathematics*, vol. 13, No. I (February 1960). New York: John Wiley & Sons

presentations of the empirical through passive observation. Galileo and Newton, on the other hand, were more concerned with mathematical approximations based on the patterns that emerged from the data which were taken in defined and restricted natural circumstances, i.e. very close to what a scientist does a laboratory environment.[6] Newton sought, through his models, to explain the elements of the phenomena through mathematically explicable forces immediately applicable thereto. Both Newton and Galileo were concerned with estimable and not demonstrable truths.

The mathematical stance always had a troubled relation to the cosmological or philosophical stance. Even at the height of Classical astronomy, one could hear the confession of all astronomers that Ptolemy sought to "save the appearances" and, the features and the imperfection of his mathematical models did not have any influence on the Aristotelian theory of the concentric circles of the heavens. Comparing the two, that is to say mathematical models with philosophical/cosmological models, gave rise to suspicion among many professors and philosophers of early modernity. And the natural sciences, as we know them today, emerged despite all the disagreements and warnings that were voiced in the 17th and 18th centuries. One might even, not altogether unjustifiably, provoke the modern reader by saying that astrology in the 18th century would be more of a science than Newtonian physics if the consent of the majority of the educated elite of Europe at the time was the determining factor.

Moreover, chemistry, a pristinely positive natural science of our times, also has a rather shady pedigree through its intimate link with alchemy and magic. The list of scientific disciplines with such shameful pedigrees would go on to cover still many others. The point I am trying to make is that it is very difficult from this point in history to judge with an impartiality and indifference what then constituted a science, a legitimate field of knowledge. The first task at hand, then, is to determine the legitimate areas of knowledge and see how the inquiry conducted in this text relates to those legitimate areas of knowledge of the times studied.

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[6] E.McMullin "Conceptions of Science in the Scientific Revolution" in *Reappraisals of the Scientific Revolution*. Ed. D.C. Lindberg and R.S. Westman. New York: CUP, 1990, p.65

This thesis deals with the historiography of Ottoman science and will therefore set out by explaining the two components of the subject-matter. What is the science(s) that we are dealing with, and what is Ottoman about this science? According to Adıvar, whose work was the first to deal exclusively with the natural sciences and mathematics in the Ottoman empire, there is no equivalent of science as such in the Ottoman language, since "science" as we use it today is a historical construct that originated in the 19th century by Whewell when he first used the word "scientist" for those then teaching and studying natural phenomena in European universities then. The closest relative, according Adıvar is *ʿilm*, which is basically the gerund of the Arabic verb "to know". He furthermore relates *ʿilm* to *savoir* and *ʿâlim* to *savant.*

1.2 What *ʿilm* is

At this point, a rather standard description of *ʿilm* is due. It is defined simply as learning and most commonly refers to knowledge that can be learnt -- as opposed to revelation and other forms of knowledge acquired through presence vis-à-vis the divine. The question of what *ʿilm* is, is a matter of dispute in many senses, both among those who adhered to a vision of *ʿilm* as an ideal of the human spirit and inquired into it philosophically, and among historians of Arabic science and philosophy. It is a question of intrinsic difficulty, very much like the question of what knowledge is or what science is. And as we cannot take a scientist's account of what science is at face value, so we cannot take the many answers provided by an *ʿâlim* as regards *ʿilm* at face value. In short, there are no signposts to follow and no authoritative sources to lean on in defining *ʿilm* in a satisfying and rigorous manner. I shall, however, take a much more humble task and, try and offer some of the opinions held by two members of the Ottoman *ʿulemâ* and by a few modern historians so as to lay a foundation and also to spell out the disclaimer to what is to follow.

All branches of learning, from grammar to history, from mathematics to biology, from philosophy to theology, from law to alchemy or divination, were traditionally called *ʿilm* until the 19th century. There have been competing theories on whether *ʿilm* only refers to only the known world, i.e., whether it is an effort to get from the known the unknown, (e.g. whether *kelâm* in order to be an *ʿilm* should restrict itself to scriptural interpretation alone). Some like Nev'î Efendi have claimed *tasavvuf qua* theosophy is an *ʿilm*.[7] Still some others have left alone the means of attainment of knowledge in defining *ʿilm*, and rather emphasized the importance of having an error-free knowledge as the final product.

ʿİlm does not refer to the natural sciences or to the religious sciences alone. However, *ʿilm* is traditionally divided between the Islamic sciences (Arabic language and Islam's cognitive apparatus) and the foreign sciences, most commonly referred to as Hellenic philosophy and science. The comprehensive character of Islamic learning as well as the duality presented reflects both a uniquely Islamic worldview, but also a shared understanding of what learning is around the Mediterranean[8] .

ʿİlm is structured and classified in an encyclopaedic tradition in Islam. The encyclopaedic tradition, also definitive of the Ciceronian approach in medieval and early modern European universities, is not unique, but is closely related to a pedagogico-philosophical approach that has ancient Greek roots, and owes especially to Aristotle. Classification is not unique to *ʿilm*, but to all science. Just as science today is an endeavor organized under disciplines and just as it is impossible to think of science independently of the entirety of the legitimate claimants of the title, it is impossible to think of *ʿilm* without taking stock of what kinds of things counted as *ʿilm*. Indeed, the effort to add, subtract, juxtapose and organize various branches of learning is well established in Islam within an encyclopaedic tradition:

> Muslim philosopher-scientists were generally interested in the problem of classification of the sciences, especially the theoretical philosophical sciences, and in the discussion of the relative merits and positions of these sciences in the hierarchy of knowledge. Some, however, were more detailed than others in

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[7] Nev'î Efendi. *İlimlerin Özü: Netâyic el-Fünûn*. ed. Ö.Tolgay. İstanbul: İnsan Yayınları, 1995. pp.191-2.

[8] Theology was the queen of all sciences until the Reformation started exerting its influence at the universities around Europe. In order to be admitted to the faculty of theology, a student needed a Bachelor of Arts degree, certifying his mastery over the secular sciences. cf. Runciman, Steven. *The Last Byzantine Renaissance*. Cambridge, UK: CUP, 1970. , p.28: Runciman claims that Byzantine education also maintained a similar distinction. Hellenic secular learning was considered outer learning, where inner learning meant Christian theology. Likewise, in the European universities of early modernity, the study of the Hellenic sciences culminated in a bachelor's degree, and the religious sciences were studied for advanced degrees.

> their treatment of the problem. But they shared many common views concerning the hierarchy of the philosophical sciences and the place of mathematics and natural science in that hierarchy.[9]

Unlike today, when method, the scientific method, makes and defines a scientific discipline, for *ʿilm* it was more the subject matter than the approach that defined areas of knowledge. Pre-modern European science also shared this organizing principle, namely that subject-matter was the determining factor in defining a science[10].

This, too, is not unique, since it was Aristotle's contention that the field of knowledge should be defined by the objects under study, since each thing should be studied according to its nature. In Europe, and among the Arab philosophers we see this approach sustained until a certain point in history. Also in Nev'î and Taşköprüzâde, two members of the Ottoman *ʿulemâ* of the 16th century, we see the sciences organized according to subject matter. Often newer branches of learning, such as engineering would find a place according to their subject matter within an already established catalogue of sciences, in this particular case under the geometric sciences.

ʿUlûm, as parts of an organized body of knowledge, are ranked among themselves by usefulness of the science and by the nobility of the thing studied. *ʿİlm-i kelâm* is noble because of its subject matter, which is God and his Quran. *Cerr-i eskal* is useful because through it we can lift weights with less force through the use of contraptions. *ʿİlm-i ahkâm-i nücûm* is useful because of its predictive power, whereas *ʿilm-i hey'et* is noble because of its subject matter, which is the stars. Philosophers, such as Al-Farabi, have also considered the "profundity of proof" as a criterion by which to rank the *ʿulûm*.[11] Ibn Sina, as well as many others, have offered overarching categories and criteria for classification. However, each of these efforts to classify has not diminished in size the body of knowledge recognized as *ʿulûm*.

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[9] Bakar, Osman. "Science" in *History of Islamic Philosophy*. Eds. Nasr, S.H andO. Leaman. London: Routledge, 2001. p.930

[10] W. Schmidt-Biggemann. "New Structures of Knowledge" in *A History of the University in Europe* vol.2, ed. H. de Ridder-Symoens. Cambridge, UK: CUP, 1996. pp.491-492.

[11] Bakar, p. 934.

Abdülhak Adnan (Adıvar), in his *La science chez les Turcs Ottomans* [Paris, 1939; later published as *Osmanlı Türklerinde İlim*. Istanbul, 1943] claims that all human knowledge was considered *ʿilm*. This, I propose, is insufficient and inaccurate. Here I would like to present certain partialities that obscure Adıvar's rather liberal use of *ʿilm*, since *ʿilm* in both the philosophical and the historical sense is quite loaded and therefore its liberal use is more likely to lead to misconceptions than to serve as a heuristic principle. I'll take Meninski's 17th century dictionary as a point of reference to further guide this inquiry. Therein *ʿilm* is defined as a series of concatenated but not entirely overlapping notions: *science, cognoissance [connaissance], doctrine, faculté, art, profession*. Here in the meaning of *ʿilm* is found both art and science, *ars* and *scientia*, *tekhnê* and *epistêmê*, the practical and the theoretical. *Ars rhetorica* is *ʿilm-i belâgah*, *ars magica* is *ʿilm-i sihr*, *ars mechanica* is *ʿilm-i cerr-i eskal*,[12] the seven *liberal arts* are all a part of *ʿilm*, the *liberal arts* constituted the foundation of higher learning in the medieval European universities. The study of the liberal arts led to the bachelor's degree (*baccelaureus artium*) and was supplemented further by medicine, law or theology in order to complete the degree of *licentia docendi*. What Schmidt-Biggemann said of *scientia* in early modern Europe holds true for *ʿilm*, and therefore is worth noting, since *scientia* covered as vast a territory as *ʿilm* did: "To define what 'science' meant for the early modern period, we must try to understand it in conjunction with its dominant formal and substantive concepts: *scientia, ars, prudentia, encyclopaedia, historia* and *philosophia.*[13]

The scope of *ʿilm* in Adıvar, as will be discussed later, is further obscured by competing terminology for the same denotative territory. *Fenn*, for example, means *industria, astutia, stratagema, ars, scientia* in Meninski's *Thesaurus*, here *fenn* extends further than *ʿilm* into practical crafts, but competes with *ʿilm* for the more theoretical knowledge, *scientia*. Much of what can be said of *fenn* can be said of *ars* in the early modern context. *Ars* usually meant whatever was practicable.

[12] F. Meninski. *Thesaurus lingrarum orientalium turicae, arabicae, persicae: Lexicon Turcico-Arabico-Persicum.* Simurg:2000 vol.2 pp.3316-7

[13] Schmidt-Biggemann. p.491. As will be discussed later, the following parallelism between the Latin and the Arabic vocabularies seems to hold true: *scientia: ʿilm :: ars: fenn :: prudentia: ma'rifa*

Furthermore, Ibn Khaldun in his *Muqaddimah* claims that scientific instruction is a craft[14] since it involves habituation, and unlike knowledge, depends on memory. And the *ʿâlim*, the scholar, alone wields the habits proper to *ʿilm* and this habituation differs from the immediate understanding every scholar, beginner or seasoned, might have. Ibn Khaldun further elaborates this problem through how teaching/learning and disputation belong to this craft while the object known is not necessarily a part of the scholar's craft. So here, *ʿilm* itself seems to be divided between the craft of its practice and its subject matter.

A still further difficulty arises when the Persian scribal tradition, codified in the dynamic notion of *âdâb*, also competes with *ʿilm*. Câhiz, a 9th century thinker from Baghdad, proposes that the applied sciences, i.e. arithmetic, geometry and practical astronomy, as well as history and the techniques required to oversee public works are all a part of *âdâb* and are proper to the *kâtib,* whereas the *ʿâlim*, Adıvar's *savant*, specializes in the religious sciences, philological sciences, ethics, and Greek philosophy as an ancillary field.[15] The classification proposed by Ikhwan as-Safâ places divination, magic, enchantment, alchemy, mechanics, arts and crafts, commerce, agriculture, livestock farming, biography and history among the sciences of *âdâb*, whereas more theoretical branches, such as physics, zoology, medicine, mathematics etc., are proper philosophical sciences.[16] Nev'î Efendi, a 16th century Ottoman *ʿâlim* and poet, entitles his encyclopaedic work *Netâyic el-Fünûn,* but the title headings invariably start with *ʿilm*. The range of *ʿilm* extends from philosophy to theology, to interpretation of dreams, to theosophy, and to agriculture. Noteworthy is the fact that the propaedeutic sciences, which are the Islamic equivalent of the liberal arts are not included in Nev'î's book.[17] While the book itself might be addressed to an already somewhat educated crowd, there is also the possibility that Nev'î is dealing expressly

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[14] Ibn Khaldun. *Muqaddimah*. tr. F. Rosenthal, ed. and abr. N. J. Dawood. Princeton: PUP, 1969. p.340

[15] C.Pellat "Les encyclopédies dans le monde Arabe" in *Etudes sur l'histoire socio-culturelle de l'Islam, 7e-15e siecles*. London: Variorum, 1976. p.638.

[16] F.Rosenthal. *The Classical Heritage in Islam*. London:Routledge, 1994[1975] pp.56-8

[17] The *trivium*: logic, rhetoric, poetics. In the *medrese* version Arab philology is also included under the trivium. The *quadrivium*: arithmetic, geometry, astronomy and music. In the *medrese* version astronomy is not considered propaedeutic in most Arab encyclopaediae.

with areas of specialization and expertise rather than with the general areas of knowledge, through which we may deduce that *fenn* denotes fields of expertise as regards *ʿilm*, the various scholarly crafts, rather than all areas of knowledge. Likewise, a curious quotation in the *ʿilm* entry in Meninski goes: *Cerr-i eskal mâhirlerinin hicret efzâ tedbirleri ile bahrdan berre çıkıldı,* where again, the mechanics are referred to as some kind of expert, but not as an *ʿâlim* as such.

Adıvar's liberal usage of *ʿilm* is also found in Taşköprüzâde who classifies almost anything that can be known as a science, and treats teaching and learning as both a certain set of habits, such as frugality, diligence and otherworldliness, and as a pious act worthy of commendation.[18] In the Turkish translation of *Miftah es-Saâde, Mevzu'atü'l-ʿulûm*, there is a group of sciences named *ʿulûm-i hattiye*, the calligraphic sciences, that deal with everything from the alphabet to the sharpening of the reed pen. It is quite clear in every sense that the calligrapher, *hattat*, is not an *ʿâlim*.

There is also a further distinction in the same conceptual vicinity, between *ʿilm* and *maʿrife*, which refer to universal sciences and particular sciences respectively. There the distinction is further explicated:

> Muslim thinking between *maʿrife* and *ʿilm*, the first tending to be used of knowledge acquired through reflexion or experience, which presupposes a former ignorance, the second a knowledge which may be described as spontaneous knowledge; in other words, *maʿrife* means secular knowledge and *ʿilm* means the knowledge of God, hence of anything which concerns religion.[19]

Here is implied that while *ʿilm* pertains to religion and might include revelation, *maʿrife* expressly means things that are learnt. *Maʿrife* also contains within it *prudentia*, i.e. practical philosophy, such as ethics, and law.

> In the science of actions, in the practical sciences, therefore, it was a matter of choosing the means to achieve a certain end appropriately, wisely, prudenter. Prudentia was the art of choosing the proper means of attaining some good, the goal of one's actions. The science of prudentia was the science of appropriate means. From the standpoint of scientific method, ethics, politics and economics were therefore regarded as practical sciences. Jurisprudence was also concerned with the legitimacy and the appropriateness of means... Practical science simply delivered the means to the end as defined by

[18] Taşköprüzâde. *Mevz'uatü'l-ʿulûm*. İstanbul, h.1313., pp.27-39

[19] "*ʿilm*" in *EI*^{2}

> metaphysics. Practical science existed *propter aliud* (for the sake of something else).[20]

The introduction of Sufi terminology into the picture further obscures the treatment of *ʿilm* and *maʿrife*. *Maʿrife* is often used to mean knowledge that precedes ignorance, a sort of a priori knowledge, which is a selfless contemplation of God, a knowing his existence through presence, as distinguished from *ʿilm-i tasavvuf*,[21] which is alternately used as *ʿilm-i maʿrife*-i *tasavvuf* and *ʿilm-i tasavvuf*, and which means both *maʿrife* as described above and as the proper complement (*ʿilm-i bâtın*) of the *ʿilm* of the known world (*ʿilm-i zâhir*).

1.3 The Encyclopaedic Tradition

Taking all that has been said as a disclaimer and a warning to what is to follow, one may further propose a connection which has been accepted and used by many scholars of Ottoman science, i.e. that between *ʿilm*, *ʿâlim*, *taʿlim* and *taʿallüm*,[22] again, most clearly expressed in Taşköprizâde and later used by modern scholars. What this thesis treats, i.e. natural and mathematical sciences in the Ottoman Empire, as has been written above, is not necessarily under the monopoly of the *ʿulemâ* since there is no proof that it was only the *ʿulemâ* that dealt with and claimed competence over the natural and mathematical sciences. Adıvar's main line of inquiry, *medrese* science, focuses on the branches of physical sciences and mathematics as taught in the Ottoman-Islamic institutions of higher learning and practiced by the graduates of such institutions. It is very well known that the main function of the *medrese* was to perpetuate the religio-judicial system of the Ottomans. *Medrese* graduates often had to choose between two career tracks, a choice they could make or change at any juncture: Teaching, or serving as a judge. So it is more than safe to assume that all *medrese* graduates knew about Islamic jurisprudence, and could read, write and speak Arabic to a certain degree. *Kevâkib-i Sebʿa*, an 18th century verse exposition of the Ottoman *medrese* curriculum shows that all *medrese* graduates must have been trained

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[20] Schmidt-Biggemann, p.492.

[21] "*Maʿrifa*" in *EI*²

[22] "*ʿilm*" in *EI*²

to be polymaths.[23] And indeed the outstanding figures of the Ottoman intellectual topography reflect that in many instances the same person could and would write works on diverse disciplines. Moreover, a *kadı*, in order to function well, would need to know enough mathematics to apply inheritance laws, enough geometry to conduct land surveys, or enough book-keeping and other things to oversee the construction of public buildings. These, on the other hand, do not necessarily bear witness to a *medrese* education that sows the seed of veritable polymaths. These are sufficient indication that all *medrese* graduates knew, more or less, a little bit of everything.

What, then, justifies Adıvar's and subsequent historians' choice to focus mainly, if not exclusively, on *medrese* science ? Most well-educated persons living in the Ottoman Empire, and in other places in the lands of Islam through the ages, were *medrese* graduates, but there were alternative routes and forms of learning. While *medrese*s were highly regulated and were organized hierarchically, there were no such well organized educational institutions that acquainted one with some basic skills, like reading and writing, performing basic calculations and reciting the Quran. Most prospective *medrese* student took care of this portion of their education in their immediate locality, for example through the imam of the local mosque. Certain things could not be learnt in the *medrese* at all, for example any language besides Arabic, be it Persian or Latin, was simply not a part of the *medrese* curriculum. Medicine was mainly taught at hospitals, where a room would be reserved for teaching future doctors. Astronomy, astrology, alchemy and the like always had a difficult time establishing a well-defined link with the Ottoman (religious) institutions of higher learning. In short, there is no intrinsic reason for us to pay exclusive attention to *medrese*-related or *medrese*-oriented science.

What were the alternatives? The secretaries of the palace and of other high-ranking Ottoman officials were also educated, sometimes in the Enderun, and sometimes simply through the knowledge they picked up as they worked as scribes. İnalcık's “Reisülküttab” article in the *İslam Ansiklopedisi* sets forth that the knowledge a secretary would have to command, if he aimed for the higher posts, often had to be

[23] E.İhsanoğlu “Ottoman Educational Institutions” in *Ottoman Civilization*. vol.1. ed. H.İnalcık & G.Renda. Istanbul: Ministry of Culture,2002. pp.357-8

encyclopaedic, and the secretary would have to be well versed in practically everything he would have to face as a part of his day-to-day professional experience. It is also well known that Sufi lodges doubled as places of learning and teaching in diverse disciplines. The observatory, although in the Ottoman case there is only one in Galata in the 16th century, also might have served to teach young natural philosophers or scientists, since such was definitely the case in Maragha.

As regards the non-muslim populations in the Ottoman Empire, the case for non-*medrese* science is much more striking. One would have to be born or would have to become at some point a Muslim in order to attend the *medrese*. Most Orthodox Greeks therefore had the Patriarchal Academy in Istanbul as the sole source of higher learning within Ottoman territory. Most Greeks acquired their education in Italy, and mainly in Padua. What more education an Orthodox Greek could acquire through non-documented ways is entirely in the dark. In short, little is known of what the Greeks did by way of philosophy and other branches of learning in the Ottoman Empire.

1.3.1 The Natural Sciences in the Encyclopaediae

Where, then, do the natural sciences fit into this scheme? I have set out to write this thesis in the hope that I'd be able to delienate the origins and determine the location of what we today call "the natural sciences" in the Ottoman Empire. This question presents many methodological problems. The natural sciences today, unlike natural philosophy, usually have applications which also emerge from within natural science. Moreover, experiments, which make man an active participant in natural processes, and which define and restrict the natural environment of the thing studied, are now an integral part of science. A history that overlooks the crucial distinction between natural science and natural philosophy is bound to confuse the history of science with the history of technology, and the history of ideas with the history of scientific discoveries.

Nevertheless, this thesis hopes to keep in sight also those disciplines that relate to natural philosophy, but are not included therein. Such disciplines include, but are not limited to, engineering, medicine and astrology. Engineering and medicine are counted among the natural sciences today. Engineering was in the Ottoman period and had been for a quite long time, although problematically, a sub-branch and a derivative of geometry:

> The study of mechanics... being useful for many important things in life, is with reason thought by philosophers to be worthy of the highest approval and is eagerly pursued by all those interested in mathematics.
> The mechanicians associated with Hero say that mechanics has a theoretical and an applied part. The theoretical part consists of geometry, arithmetic, astronomy and physics, the practical part of metal-working, building, carpentry, painting and the manual activities connected with them...[24]
>
> Eudoxus and Archytas had been the first originators of this far-famed and highly-prized art of mechanics, which they employed as an elegant illustration of geometrical truths...
> But because of Plato's indignation at it [mechanics], and his invectives against it as the mere corruption and annihilation of the one good of geometry, which was thus shamefully turning its back upon the unembodied aspects of pure intelligence to recur to sensation, and to ask help (not to be obtained without base supervisions and depravation) from matter; so it was that mechanics came to be separated from geometry, and, repudiated and neglected by philosophers, took its place as a military art.[25]

Furthermore the affinity between natural philosophy and the various branches of engineering, even at the nominal level, also remains ambiguous for similar reasons as its relation to geometry: Both natural philosophy and geometry imply theory and works with ideal and perfect truths, but engineering implies practice and deals with applicable but approximate truths, most especially mathematical modelling of natural phenomena as well as the design of devices and contrivances to control and manipulate nature. Medicine, often considered a part or culmination of natural philosophy (at least academically) is also a natural science. Today, it differs from the rest of the natural sciences; although it remains a science, it stands alone in terms of its methods and practices.

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[24] Lloyd, G.E.R. *Greek Science After Aristotle*. Vol.2. p.91-92 (Quotation from Pappus *Mathematical Collection* (VIII,1-2) early 4th c. A.D.)

[25] Plutarch. "Life of Marcellus" in *The Lives of the Noble Grecians and Romans*. Chicago:Britannica, 1988.

It is quite clear to all who have tried to answer the question of what *ʿilm* is, although these people are far fewer than those who tried to explain what "science" is, have invariably failed in one sense or another. The question itself is a great one, and it is not likely that anybody will go any further than producing an educated opinion. Therefore, I obviously do not claim to do any better than the line of distinguished philosophers, sociologists and historians that have been curious about what *ʿilm* is and have tried to satisfy this curiosity in various ways. Since the subject matter at hand is Ottoman Science, natural and mathematical sciences especially, I will set out by Adnan Adıvar's description and perhaps justification of what *ʿilm* stands for:

> Among the Ottoman Turks and in the East, *ʿilm* meant, quite indiscriminately, the entirety of human knowledge. Religion, with its theology and law, astrology, magic, alchemy, dream interpretation were all included in the framework of *ʿilm*... All *ʿilm* would be studied in establishments called *medrese*s. These establishments, which were the equivalents of the French *college de religieux,* were actually the Ottoman universities. *Medrese* graduates invariably took the title of *ʿâlim*, the word *ʿulemâ*, which made its way into the French language, is the plural of this word that corresponds to the French savant. The wielders of this title claimed compterence in theology, religious law, astronomy, mathematics and astrology.[26]

ʿİlm here is considered to have two properties: 1) That it is comprehensive across all branches of learning. 2) That the *ʿulemâ*, the wielders of *ʿilm*, of the Ottoman Empire claim competence over the entirety of religious and secular learning. This view of *ʿilm* and *ʿâlim* is not unique to the Ottomans. In fact, the intellectual history of Islamic societies reveals that every *medrese*-educated intellectual claimed degrees of such universal competence and they reflected such claim to competence in the variegation and quality of their works. Similarly, a professor in Europe laid similar claims to the

[26] Adıvar, p.6: "Osmanlı Türklerinde ve esasen Doğuda ilim kelimesi, bütün beşeri bilgileri, hiç ayırt etmeksizin, içine alan çok geniş bir anlam taşırdı. Kelamı, fıkhiyle din, nücum ilmi (astroloji), sihir, sima ilmi, simya ilmi (fantasmagorie), rüya tabiri hep ilim çerçevesi içine girerdi... Bütün bu ilimler, medrese tabir olunan müesseselerde okutulurdu. Bu Türk müesseselerinden bahsedildikçe Fransızcaya college de religieux diye tercüme mutat olan bu medreseler, hakikatta Osmanlı imparatorluğunun üniversiteleriydi. Bu surette medreselerin mezunları "âlim" unvanının alıyorlardı ki, Fransızcaya bile geçen ulema kelimesi savant mukabili olan bu kelimenin çoğuludur. Bu unvanı taşıyanlar, kelam, fıkıh, tıp, heyet, matematik ve nücum ilmine vakıf olma iddiasındaydılar."

entirety of learning until the 18th century. Regarding the how and the why of their claims, I will tread a path that has been frequently travelled, but I will also try and offer a more synthetic approach so as to accommodate all that can be meant by *ʿilm* across centuries. I will first be dealing with a certain encyclopaedic tradition in Islam, since the writing of encyclopaediae has been an effort persistent through centuries among many learned men, be they Christian or Muslim. Because of the peculiarity of Islam, especially its religious and theological apparatus and its mysticism, but also because of the scribal tradition it seems to have borrowed from the Persians, seems to have contributed to its encyclopaedic tradition, I will confine myself to a brief treatment of the various organizational schemes for knowledge among Muslim encyclopaedists.

As early as Plato, one could see the notion that although human knowledge constituted a whole at work, but also that it was a whole with parts, and that natural philosophy was not the same thing as metaphysics. Aristotle fortified this otherwise vague distinction first through his treatment of the branches of knowledge in the *Metaphysics*. In the *Metaphysics*, Aristotle distinguishes between three kinds of speculative philosophy: the mathematical, the natural and the theological. The distinction among the various branches of practical philosophy, i.e. ethics, economy and politics, would be explicitly spelled out later, by Porphyry.[27] Moreover, Aristotle as an ardent believer in studying things in a manner proper to their nature, laid out his various works according to subject-matter. Aristotle's *Organon*, organized in this way also became a model for later classifications of the sciences. The Aristotelian classification reflects the view that all kinds of beings are studied based on their kind, and require the kind of contemplation proper to their nature: for example, one should study plants as part of nature, i.e., in motion and should seek the soul proper to the plant.[28] Aristotle's classification was therefore largely descriptive of types of knowledge, and presented a means through which one could acquire knowledge. Aristotle's initial classification underwent an ossification both in the West, and in

[27] Rosenthal, p.28

[28] Aristotle.*Metaphysics* 1025b3-1026a20

Islam.[29] In the following pages I'll attempt to chart out a brief history of the classifications in order to understand not only the paedagogical aspects of such classification, but also how knowledge is perceived and what kinds of knowledge are considered to be of the same kind, by means of which one may hope to understand what *ʿilm* is.

The first work to be considered is al-Kindi's *Fi aqsâm al-ʿulûm*, in which Kindi repeats the Aristotelian distinction between theoretical and practical philosophy, natural philsophy belonging to the former. He furthermore claimed that

> ...knowledge of the true nature of things includes the knowledge of Divinity, unity and virtue, and a complete knowledge of everything useful, and of the way to it, and a distance from anything harmful, with precautions against it.

He thereby divided knowledge in general and philosophy in particular into two main parts, those that related to religion (theoretical philosophy) and, virtue and the useful sciences (practical sciences).[30] Al-Kindi introduced a further, this time ontological, division between material(created, movable) and immaterial(divine, immovable) entities. Divine Sciences here are sharply separated from everything else.

After Al-Kindi's must be considered Al-Farabi's division in his *Ihsâ al-ʿûlum*. Al-Farabi divides the sciences into 5 main parts: 1)The Sciences of Language, 2) Logic, 3) Ancillary Sciences, 4) Physical and Metaphysical Sciences, 5) Social Sciences. As will be discussed later, Al-Farabi's division is paedagogically optimized. Language precedes logic, which is the equivalent of the *trivium* (logic, rhetoric and poetics), which in turn precedes the ancillary sciences, which are the *quadrivium* of the Liberal Arts (arithmetic, geometry, music and astronomy). Then comes the physical and metaphysical sciences, which includes physics as such, minerology, natural history, zoology and metaphysics proper. These, too, by their virtue of succeeding the *trivium* and the *quadrivium*, follow the Aristotelian scheme and roughly correspond to the various titles of Aristotle's works on physical and metaphysical sciences. All of this is

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[29] D.Gutas. *Avicenna and the Aristotelian tradition : introduction to reading Avicenna's philosophical works.* Leiden: Brill,1988. p.149

[30] Bakar, 928

followed by the Social Sciences, which again following Aristotle, are divided into Law, Politics and Economics. [31]

A similar structure seems to permeates the European system as well, a structured study of the Organon, starting with things better known to us, *Prior* and *Posterior Analytics* and *Peri Hermeneias*, study of the various natural-philosophical works, followed by Ethics was a pre-requisite in order to work on the higher sciences, i.e. Theology, Medicine and Ecclesiastical and Civil Law, and one could not acquire a *licentia docendi*, i.e. become a doctor, without the higher sciences. A similar pattern is found in the *medrese* system, where one cannot graduate without learning the divine sciences.

A far more original division among the sciences is made by Al-Khwarizmi. In his *Mafâtih al-ʿulûm*, he organizes the various branches of knowledge.[32] This is a work which was first studied by Eilhard Wiedemann, and now is taken to be the first genuine encyclopaedic work as such in Islamic intellectual history. Allegedly, it is a work written for the *kâtib*, and aims to acquaint the *kâtib* with scientific/philosophical terminology as well as with organization of the various sciences. The often repeated difference between Islamic and foreign sciences is underlined in Al-Khwarizmi's lexico-encyclopaedic work.[33] Here we see a distinction that goes against the pedagogical spirit of Aristotle's Organon. The Islamic and Arabic sciences, mentioned first, are law, theology, grammar, the art of the secretary, poetry and prosody, and history.[34] The foreign (*acemî*) sciences are, respectively, philosophy, logic, medicine, arithmetic, geometry, astronomy and astrology, music, mechanics and chemistry. Philosophy is divided into the branches of the theoretical and the practical and is concluded with metaphysics (*ʿilm-i ilâhi*).

[31] M. Bayrakdar. *İslam'da bilim ve teknoloji tarihi*. Ankara:Diyanet Vakfı, 2000.pp.14-15

[32] C.E. Bosworth "A Pioneer Arabic Encyclopaedia of the Sciences: Al Khwarizmi's Keys of the Sciences" in *Isis*. vol.54/1. 1963

[33] Bayrakdar, pp. 13-14

[34] Bosworth, p.103.

In his article, Bosworth pays special attention to the relationship between ʿ*ilm* and *âdâb*. *Âdâb* means "advancement of the mind", even beyond belles-lettres. Câhiz, an eminent scholar of the 9th century, goes on to describe further in his encyclopaedic work, *Âdâb al-Kâtib*, the education of the secretary*(kâtib)* in *âdâb* as consisting of: 1. Philology; 2. Applied sciences: Arithmetic, geometry, practical astronomy; 3. Techniques of public works; 4. Rudiments of jurisprudence; 5.History (in anectodes); 6. Ethics.[35] The meaning also rings true in the Ottoman setting.[36] *Âdâb*, among the Abbasids as well as the Ottomans, was the virtue of the *kâtib*, the secretary. A secretary was, first and foremost, required to know Islam. The knowledge of Arabic, in the Ottoman case, Turkish and Persian as well, calligraphy and various linguistic arts also were indispensable. In addition, as both Bosworth and İnalcık maintain, the secretary would have to have an encyclopaedic knowledge of various branches of knowledge of practical use, from accounting to construction,[37] sometimes even astrology, mechanics, magic and medicine. Al-Khwarizmi desired his work to introduce the *küttâb* to the various intricate and peculiar vocabulary of the sciences, some of the fundamental problems, certain useful facts, such as weights and measures, an inkling of pre-Islamic, Persian and Islamic history, and in short, some understanding of the entire breadth of possible human knowledge which would prove useful.

Avicenna's education, treated by Gutas, also constitutes some kind of organization of knowledge.[38] Gutas sets out to treat Abu-Sahl's A*l-Mâsihî's Kitâb fî Asnâf al-ʿulûm al-hikmiyya*, which he considers a rather standard work that has the extra benefit of providing a syllabus --which was also followed by Avicenna. The sciences are divided into four main sections: Logic, the particular sciences, the universal sciences and practical philosophy. It should be kept in sight that Abu-Sahl treats only the philosophical sciences and conspicuously steers clear of Arabic and Islamic sciences, such as grammar and theology. The division is fairly standard: first under the heading of logic the *trivium* is treated, and then in the first part of the particular sciences are

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[35] Pellat, p.638

[36] "Reisülküttab" in *IA*

[37] Bosworth, p.99

[38] Gutas, 1988., pp. 149-159

treated the mathematical sciences, i.e. the *quadrivium*. This is followed by mechanics, medicine, agriculture and alchemy. Then comes the the natural sciences (meteorology, physics, natural history, etc.), and metaphysics under the heading of the universal sciences. Then comes practical philosophy (ethics, economics and politics). The scheme is very much Aristotelian in the paedagogical sense.

Although Avicenna is first acquainted with the Koran and then with jurisprudence; and studies the various philosophical sciences with periodic interludes of Islamic sciences, he nowhere mentions his acquaintance with the Islamic sciences and, instead, he claims that his philosophical study of the Organon led him to knowledge itself *al-ʿilm*,[39] thereby claiming that the various Islamic sciences do not partake of this scheme of knowledge, something that will be discussed below.

Es'ad Yanyevî, an 18th century Ottoman *ʿâlim* constitutes good evidence for the continuity of the general outlook of the encyclopaedic tradition. He divided philosophy into two main portions, of the theoretical (*nazarî hikmet*), included metaphysics, mathematics and natural philosophy(*hikmet-i tabiʿiyye*). Mathematics was further divided into geometry and arithmetic, and geometry, and not natural philosophy, included all the engineering-type sciences which we consider to be the most useful today.[40]On the other hand, he further drew a connection between mathematics and natural philosophy, and claimed the former influenced the latter.[41]

In his *Mevz'uatü'l-ʿulûm*, Taşköprüzâde remarks that whosoever wishes to be an *ʿâlim* should know an inkling of every science.[42] The scheme of organization that Taşköprüzâde follows is pedagogical. The propaedeutic sciences are treated first and the subject-matter gets increasingly complex and profound. He first sets out to treat the *ʿulûm-i hattiye*, the art of writing. It makes paedagogical sense that one should first be able to read and write the alphabet properly and should be acquainted with the

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[39] Gutas, 1998. p.158

[40] K.Sarıkavak. *XVIII. Yüzyılda Bir Osmanlı Düşünürü: Yanyalı Esad Efendi.* Ankara : T.C. Kültür Bakanlığı, 1997. p.87

[41] ibid., p.90

[42] Taşköprüzâde. p.55

book at the most physical level in order to engage in learning. Taşköprüzâde's choice for the second field of treatment is language. Again, pedagogically it makes perfect sense that a student should know grammar and syntax, and the various literary arts lest he fall into the traps of misreading. The third party of sciences comes as the secondary arts of the intellect, such as logic and argumentation, perhaps referring to the old debate among the Arabs concerning whether language or logic has the primacy in determining truth. Afterwards Taşköprüzâde ventures into philosophy and its various branches, in which are included most of the arts and sciences. Ethics to medicine to magic is included under this heading. Then follows the systematic treatment of religion, such as *kelâm* and *fıkıh* and the book is concluded with the secrets of religion, i.e. the inner meaning of the religious sciences: theosophy.

This is reminiscent of the organization of study in early modern Europe. The liberal arts, followed by physics and metaphysics, are studied before embarking upon the queen of sciences: theology. Here, it must be noted that in the early modern era philosophy as we think of it, a discipline critical of and overseeing all other disciplines, did not play the same role. Philosophy paedagogically preceded all other disciplines, but had not the primacy it later acquired during the Enlightenment.

Although the space allocated to philosophers such as Suhrawardi, Shirazi and Tûsi, implies an illuminationist streak in Taşköprüzâde's thought, there seems to be a certain adherence to Aristotelianism in education. Illuminationism may be narrowly defined as a neo-Platonist theory of emanation, and is not entirely opposed to the Aristotelian scheme of learning. Indeed, the two are very much intertwined in the organization of knowledge laid out by Taşköprüzâde and Nev'î.

Aristotle makes a simple distinction between those things that are better known to us and those things that are better known by nature. The pure rational sciences, such as mathematics and hermeneutics, are better known to us since they relate to human reason and human language. The sciences that go beyond excursions into the human mind are those that deal with things better known by nature, such as physics and botany. To learn these, we need to train our minds so as to make ourselves proper receptacles to such knowledge and to observe the object of our study. I would claim, based on the organization of knowledge laid out by Taşköprüzâde, as well as Nev'î that this Aristotelian distinction, with the introduction of a certain amount of religiosity and Islamic cosmology, becomes a distinction between those things that are better known to us and those things that are better known by Allah.

Moreover, what we know of this world, short of the knowledge of Allah is incomplete, since while pedagogically we must start by the simplest things that are better known to us, the highest form of knowledge comes from above and one cannot duely appreciate the intermediate stages of learning unless one has the knowledge of God, i.e. one cannot consider himself learned (*ʿâlim*) unless one has a grasp of the whole. This notion of education reflects the ideal of a universal man[43] that was valued in the entire Mediterranean ecumene of learning. When one treats the essential and essentialist distinction between the Islamic and the foreign sciences, one must keep "the better known to us" / "better known by God" distinction and inquire whether one can place natural philosophy in a necessary spot within this scheme of universal learning. It is noteworthy that, for example, *ʿulûm-i hattiye* are sciences. One may very well ask, once again, whether any calligrapher was considered to have *ʿilm* or whether *ʿulûm-i hattiye* were a part of *ʿilm* only insofar as they partook of the universal learning. The latter seems to make more sense since even the most famous calligraphers, such as Şeyh Hamdullah were not considered *ʿâlim*s. One may take this line of thinking further and say that most *etıbbâ* were not *medrese* graduates and therefore were not *ʿâlim*. A quick glance at the variegated titles given to the Ottoman *hekimbaşı*s, that not all of them were *efendi*s, i.e. were not trained as a *kâtib* nor as an *ʿâlim*, as well as the various foreign medical doctors would be sufficient to make this point. These were people who worked with *ʿilm-i tıbb*, but were not *ʿâlim*'s. The claim that Ottoman *ʿulemâ* were at least nominally *doctores universales* could be taken further. One may claim with justification that only the universal doctor was an *ʿâlim* and something was an *ʿilm* only insofar as it partook of the scheme of universal knowledge.

[43] P.Burke. *A social history of knowledge : from Gutenberg to Diderot*. Malden, MA : Blackwell, 2000 p.94

2. GREEKS AND OTTOMANS IN EARLY MODERNITY

2.1 The Byzantine Heritage

Byzantine intellectual heritage has contributed to the intellectual life of the subsequent generations of Greeks and Ottomans. Its influence on the Italian Renaissance is also well known. That there is continuity between ancient Greek and Byzantine thought, and between Byzantine thought and post-Byzantine Greek thought has often been claimed. [44]The Byzantine thought that was represented in the latter centuries was mainly the product of the fourteenth and the fifteenth centuries, which has been called a Byzantine Renaissance by Runciman[45], echoing both the Italian Renaissance and the 11th century Byzantine renaissance in the field of the arts.

What has been called the latter Byzantine Renaissance is associated with a revitalization of Greek learning. Under the Paleologan rule from the 14th century onwards, Byzantine Empire experienced what Runciman calls re-Hellenization, intellectual as well as political. Neo-Platonism was especially popular in this era. During this era, Byzantine territory was by and large reduced to the city states of Constantinople, Thessalonica, Trebizond and Mistra. This seeming decline went hand-in-hand with the rise of ancient Greek thought among the learned.[46]

Byzantine learning, similar to its Islamic counterpart across the border, was divided between the outer and the inner sciences. These were Hellenic secular learning and Christian theology respectively.[47] Hellenic secular learning acquired increasing

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[44] R.Demos "The Neo-Hellenic Enlightenment" *Journal of the History of Ideas.* Vol.19/4. 1958. / G.P.Henderson "Greek Philosophy From 1600 to 1850" *The Philosophical Quarterly.* Vol.5/19. 1955. /S.Runciman. *The Great Church in Captivity*. Cambridge:CUP,1985. / Dialetis, D., K. Gavroglu and M. Patiniotis. "The sciences in the Greek-speaking regions during the seventeenth and eighteenth centuries", in Kostas GAVROGLU (ed.), *The Sciences in the European Periphery during the Enlightenment*. *Archimedes*, vol. 2 [series editor Jed Buchwald], Dordrecht, Kluwer, 1999. (referred to as Dialetis et al. below)

[45] S. Runciman *The Last Byzantine Renaissance*. Cambridge: CUP, 1970

[46] Runciman. 1970 pp.1-2, 22-23

[47] Runciman. 1970. p.28, also consider the akli *ʿilm* & nakli *ʿilm* distinction

prominence among scholars such Gregory Choniades[48], who founded an academy in Trebizond for the study of astronomy or George Chrysococces, who also was an eminent astronomer.There is a historiographical debate concerning this period on whether humanists and secular thinkers of the Late Byzantine period migrated, even before the fall of Constantinople, to Italy due to political decline:

> "A few teachers who had been educated in the old days before 1453 managed to keep the tradition of learning alive and to teach pupils. But the results were meagre. We know of not a single Greek of intellectual distinction living within the bounds of the Ottoman Empire during the later fifteenth century and the first half of the sixteenth. There were distinguished Greeks alive at the time; but they were to be found in the West, mainly at Venice. Indeed, we can only tell that the tradition was not lost by the fact that towards the middle of the sixteenth century a number of Greek scholars begin to emerge who had never travelled abroad." [49]

The influence and the contribution of Greek scholars, especially of Cardinal Bessarion to Renaissance humanism in Italy is quite well studied, mainly through the work of J. Monfasani[50], since as native speakers of Greek and as followers of a Byzantine tradition that had significant elements of ancient Greek thought, they would feed and initiate and support a new wave of humanism in Italy. Moreover, such scholars who travelled to Italy also helped synchronize Arab scholarship with Italian scholarship. Jamil Ragep, who had argued for the possibility of non-textual transmission in regard to Tusi's influence on Copernicus[51] later argued that there is textual evidence for Cardinal Bessarion having carried astronomical manuscripts from Iran to Vatican[52], since Regiomontanus, an important precursor to Copernican astronomy dedicated his

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[48] Runciman. 1970. p.52. see also David Pingree "Gregory Choniades & Paleologan Astronomy" in *Dumbarton Oaks Papers,* 18. 1964

[49] Runciman. 1985. p.209. cf. Henderson., p.157: In Tatakis's La Philosophie Byzantine there is a remark to the effect that from early classical antiquity to the 15th century, and from the 15th century to our own days, Greek reflective thought continued without significant interruption, and can mostly be studied in writings which it has left behind it.

[50] See, for example, J. Monfasani. Byzantine *Scholars in Renaissance Italy: Cardinal Bessarion and other emigres: selected essays.* Aldershot: Variorum, 1995

[51] J.Ragep. "Tûsî and Copernicus: The Earth's Motion in Context" in *Science in Context* vol.14/1. CUP, 2001

[52] J.Ragep "Ali Qushji and Copernicus", lecture delivered at ARIT, Jan 3, 2005.

work to Bessarion and there is a Greek manuscript from this period, outlining the Tusi couple.

2.2 Greek Learning after 1453

While it is impossible to study Ottoman science to any degree without referring to the *medrese*, that most studies have focused exclusively on these Islamic educational institutions has shaped, limited, and warped, our understanding of scientific activity in the Ottoman Empire. Not only does this view overlook some very important aspects of the history of early modern science, such as scholarly networks and patronage relations, but also the scholarship and the scientific activities of those among the *millet*s who were categorically excluded from Ottoman education. Ottoman Empire was a multi-ethnic empire from a very early stage onwards and non-Muslims , with or without converting to Islam, have contributed significantly to Ottoman political and intellectual life. Focusing entirely on the *medrese* in narrating the history of science in the Ottoman Empire naturally excludes all such non-Muslims who served the palace (e.g. *taife-i efrenciyan*, or the various palace physicians) and continued and further developed scientific and philosophical traditions (e.g. Byzantine scholarship, or neo-Aristotelianism which emerged in Padua in the sixteenth century and was widely supported among Ottoman Greeks).

There seems to be a number of channels through which Ottoman intellectual life was in interaction with the intellectual life in Europe. One of them is the presence of various European embassies and missions as well as Italian colonies in Istanbul. Another channel was the Byzantine library that Mehmed II inherited[53] as well as the steady influx of books written or printed in various European languages[54], not to

[53] F. Babinger. *Mehmed the Conqueror and His Time*. tr. Ralph Manheim ; ed. William C. Hickman. Princeton : Princeton University, 1978. pp.500-501. Also see A.Adıvar pp.33-39 for a good list of the various scientific works and the sources that can be consulted

[54] Babinger, pp.502-506 / S.Brentjes "On the Relation Between the Ottoman Empire and the West European Republic of Letters (17^{th}-18^{th} centuries)" pp.121-148. p.129 in *International Congress on Learning and Education in the Ottoman World* /Istanbul 12-15 April 1999/ Proceedings., Istanbul: IRCICA, 2001. / E.İhsanoğlu "Ottoman Science in The Classical Period and Early Contacts with European Science and Technology" in *Transfer of Modern Science & Technology to the Muslim World.* Ed. E. İhsanoğlu Istanbul: IRCICA, 1992. / D. Gutas *Greek Thought, Arab Culture: The Graeco-Arabic Translation*

mention the various European maps. Moreover, there seem to be intellectual networks connecting the Ottomans to the European Republic of Letters in the 17th and the 18th centuries[55] . Furthermore, many individuals from Europe travelled to the Ottoman Empire to serve the palace or to make a living through other means. Many non-Muslim physicians with local or European training are known to have practiced their art in the Ottoman Empire.[56] Jesuits and other missionaries may also have contributed something to the intellectual life, although nothing is known about it.[57]

This chapter will serve as an introduction to possible multi-cultural, multi-ethnic approaches to Ottoman science and will focus on philosophy and science among the Greek populations of the Ottoman Empire. The Greek population has been chosen for several reasons, by none of which this chapter tries to attribute an exlusive and extraordinary role to the Greeks in the Ottoman history of science. From the fifteenth century onwards, Greeks had, first through the Venetians who controlled parts of the former Byzantine Empire until the sixteenth and seventeenth centuries, then through the Patriarchate and also through independent means, a connection with the universities in the Italian peninsula.[58] Scholarship on this connection goes back to the beginning of this century, but in the last few decades has been studied substantively.[59]

Movement in Baghdad. Florence,KY: Routledge, 1998., p.175. / also see below Taqi al-Din's contact with European works on clockmaking in the court of Semiz Ali Paşa, A. Kazancıgil. *Osmanlılarda Bilim ve Teknoloji* Istanbul: Ufuk, 2000. p.195

[55] see Brentjes, Pippidi and Frampton below.

[56] N.Sarı & M.B. Zülfikar "Paracelsusian Influence on Ottoman Medicine in the Seventeenth and Eighteenth Centuries" in *Transfer of Modern Science & Technology to the Muslim World.* pp.157-180, see esp. pp.165-6. / Adıvar pp.33, 69-70 / Kazancıgil, p.117, p.142

[57] M.B. Hall "The Royal Society and Italy 1667-1795" in *Notes and Records of the Royal Society of London*. Vol.37/1. August, 1982. pp. 63-81. see esp. p.74, 78: Two Archbishops serving in the Ottoman Empire, Celestino Galiani and Michel Angelo Giacomelli were fellows of the Royal Society.

[58] de Ridder-Symoens, vol.2 p.440: Most students from Cyprus (ruled by Venice until 1570) and Crete (ruled by Venice until 1669) studied at Padua even after their countries fell under Turkish domination, and together formed an overseas nation (*nazione oltremarina*) there. Isolated Greek students (*Graeci*) are recorded in universities north of the Alps, and a few dozen Turks are known to have studied in Holland in the seventeenth century.

[59] see, for example, D.J. Geanakoplos *Greek Scholars in Venice*: *Studies in the Dissemination of Greek Learning from Byzantium to Western Europe.* Cambridge, Mass. 1962.

Of the universities that Greeks attended in Italy, Padua was especially important. The University of Padua, because of its proximity to Venice, had been the preferred institution of higher education among the Greeks for generations.[60] Greek students of theology and medicine acquired their education there and not a small fraction of these students later came back to Ottoman territory to practice medicine or to serve the Patriarchate in various offices.[61] Nicholas Mavrocordato in the 18th century, was a phanariot educated in Padua and became a dragoman at the Sublime Porte, and later was appointed the Prince of Romania.[62]Padua, naturally, was exposed to many of the ideas and debates that developed in the advent of modern science since Galileo, as well as many other important auxiliary figures of the Scientific Revolution, was still teaching there when he built his telescope.

Therefore, the Greek reaction to modern science is especially worth noting since their reaction is not too different from the Ottoman reaction, but their position seems to be better articulated since they were better exposed to the New Science that was brewing and developing in Europe in the 17th and 18th centuries. The Greeks (under Ottoman or Venetian rule) had partaken of the debates on modern science in Italy,

[60] Runciman, 1985. p.212: Venice had a further advantage to offer. Nearby was the University of Padua. It had been founded in 1122 and from the outset had been famed for its medical andits philosophical studies... The University of Padua was one of the first to encourage the study of Greek; and Greeks who could lecture on Greek texts were especially welcome. A Chair of Greek was founded there in 1463 and given to the Athenian Demetrius Chalcondylas. / also see pp.407-408 in "A Greek Collection in Padua: The Library of Gian Vincenzo Pinelli (1535-1601)" in *Renaissance Quarterly*. vol.33/3. 1980. 386-416

[61] Runciman, 1985. p.213: Young men who desired to enter the Church and who found the education provided by the Patriarchal Academy inadequate could study up-to-date philosophy there and thus equip themselves to deal withthe hostile propaganda with which their church was faced; and if they were intelligent they were welcomed there as native authorities on the Greek language. Boys who felt no special religious vocation gravitated towards its famous medical schools. Medicine offered a promising career in the Ottoman Empire; for few Turks woul demean themselves to do the hard work that a medical training involved, and thus became dependent upon Greeks or Jews for their physicians.

[62] Pippidi, pp.158-9

and have been members of intellectual circles that occupy a significant part of history of science scholarship on Italy. [63]

Moreover, the Greeks have played a key role in the transmission of ideas from the Arabic scientific ecumene to Europe and vice versa. We may, therefore, justifiably assume that the Greeks were literally between the two worlds, although their intellectual interests were also shaped by religious and native factors. Greek scholars have contributed significantly to the appropriation of Byzantine heritage by the Ottomans. Scholars such Amirutzes, George of Trebizond, Plethon and Bessarion have played significant roles in transmission either to or from Europe in the 15th century. The Ottoman interest in modern science in the eighteenth century was shared by Greek scholars.[64] Although no Ottoman Turks or Greeks were members of the Royal Society in the 17th and 18th centuries, an article by R.P. Stearns conveniently lists the Royal Society members who resided in the Ottoman lands, or visited there for lengthy periods[65], and the work of Andrei Pippidi unveils some of the intellectual networks that incorporated Europeans, Greeks and Ottomans alike.[66] Studying Greek intellectual history for possible non-Muslim contributions to Ottoman science also seems practically expedient, since studies on Greek philosophical and scientific thought exceeds in number studies on science and philosophy among other millets, while there is some literature on the Jews, who were also well connected with European scholarship and science.[67] Here, too, one finds much sentiment against Copernican

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[63] Runciman, 1985. p.221-222: The Greek scholars who had gone to Padua and had taught the professors there to study the ancient philosophers in their original tongue had helped to give birth to a new school of philosophy, a school of Neo-Aristotelians, whose chief spokesmen were Pietro Pomponazzi, who lectured at Padua and Bologna in the early sixteenth century, and Cesare Cremonini, who was a professor of philosophy at Padua not quite a century later. The doctrine they taught was a type of philosophical materialism. Matter is the permanent basis of everything...

[64] Demos, pp.531,533

[65] R.P.Stearns. "Fellows of the Royal Society in North Africa and the Levant, 1662-1800" in *Notes and Records of the Royal Society of London*. Vol.11/1. 1954. pp.75-90

[66] Especially noteworthy are Pippidi's studies of a certain Daniel de Fonseca pp.238-252, and of Mavrocordato, pp.218-222. Andrei Pippidi. *Hommes et idées du Sud-Est européen à l'aube de l'âge moderne* Bucharest : Editura Academiei, 1980

[67] A. Neher. "Copernicus in the Hebraic Literature from the Sixteenth to the Eighteenth Century" in *Journal of the History of Ideas.* Vol.38/2. 1977. pp.211-226.

ideas, despite the number of texts that have mentioned Copernicus from 1616 onwards -- from which seems to emerge a pattern of philosophical resistance to new science among non-Europeans.

In an article that introduces the current state of scholarship on science among the Greeks in the 17th and 18th centuries, written by D. Dialetis, K. Gavroglu and M. Patiniotis, the following general observations were made concerning science among the Greeks: 1)That Greek intellectual life had two axes of influence: ancient Greek thought and christian Orthodox tradition.[68] 2)Because the Greeks did not have any centrally administered institutions besides the Church, therefore most of the Greek intellectual life took place outside state institutions.[69] 3)When Greeks were exposed to ideas associated with modern science, they refused to adopt the discourse used by European adherents of modern science, but rather tried to come up with a new discourse associating the new ideas with ancient Greek thought. 4)Most books on science written by Greek scholars during the Scientific Revolution were intended for education. Their work wasn't geared towards the production of knowledge as such.[70] In the light of these general remarks, these scholars reject that there was a transmission of modern science from Europe to the Greek periphery. Instead, modern science was *appropriated* by the Greeks, and a similar claim is made for the Ottoman case by İhsanoğlu, which will be discussed below.[71]

The arguments set forth in this article seem to hold true at different levels for Ottoman science as well. The influence of Arabic as well as Greek thought and Islam on Ottoman thought is undeniable. Ancient Greek philosophy and science had been comprehensively translated and later appropriated by the Arabs in the eighth and ninth centuries. Greek thought appropriated by the Arabs and the philosophical traditions built on this heritage had tremendous influence on the Ottomans and

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[68] Dialetis et al. p.42

[69] Dialetis et al. p.43

[70] Dialetis et al. p.44

[71] See E. İhsanoğlu "The Introduction of Western Science to the Ottoman World: A Case Study of Modern Astronomy (1660-1860)" in *Transfer of Modern Science and Technology to the Muslim World: Proceedings of the International Symposium on 'Modern Science and the Muslim World'*. Istanbul: IRCICA, 1992.

constituted the canonical corpus most Ottoman scholars revered and referred to in their writings.

While Ottoman Muslims were entitled to get higher education in the *medrese*s, these *medrese*s did not correspond to the modern university that emerged in 19th century Germany, but rather to the modern college in the sense that their only function was education. Research and the production of knowledge was not on their agenda. Most works displaying a high level of intellectual achievement were written either through private means or through private patronage, either by the palace or by Ottoman officials and grandees. While this is the case, most such works were also written for educational purposes and a good number of them were commentaries on Arab classics.

Last but not least, the introduction of modern science to the Ottoman Empire involved not only transfer as such, but also appropriation. The agenda behind such appropriation was uniquely Ottoman and the resultant works were often syntheses of Western science with other native elements. Keeping such similarities and their possible reverberations in mind, a treatment of science and philosophy of the Greek populations living in the Ottoman Empire might be embarked upon.

After the conquest of Constantinople by the Ottomans, the Greek intellectual heritage seems to have continued without significant interruption.[72] Gennadios Scholarios, the first Orthodox Patriarch appointed by the Ottoman Sultan, was an eminent scholar and founded the Patriarchal Academy[73], which would later become a meeting point for scholars educated in the Ottoman Empire and those educated in Italy.[74]

Yet, indeed more lively was the Greek intellectual life in Venice. Since "most of the Greek scholars of his [Epirot Maximus (b.1480)] and the following generations who were educated in the West had the initial advantage of being born in Venetian-held

[72] Demos, p.523

[73] Dialetis et al. 1999, p.46

[74] Runciman. 1985. p.213-215, H. de Ridder-Symoens. p.445

territory, so that it was easy for them to go to Venice."[75] These Greeks who were then at Venice, Padua and Rome became teachers of Greek and participants of humanism which began with the Renaissance and experienced an upsurge in mid-sixteenth century as neo-Aristotelianism.[76] This phenomenon is particularly worthy of study, since there seems to be an ambiguity concerning the sources of this neo-Aristotelianism, or better still, in this sixteenth century phenomenon we find a constructive interference, as it were, between two waves of thought, Averroism and neo-Aristotelianism.

That Padua had been the bastion of Averroism since the fourteenth century[77]. Of course, here Averroism must be considered to go hand in hand with Aristotelianism, since during the High Middle Ages, the knowledge of Aristotle was acquired through a lens of either Scholasticism or Averroism, Averroism denoting a radical and more pagan brand of Aristotelianism. Profuse amounts of commentaries on Aristotle by Avicenna and Averroes were to be found in the European Universities from the Middle Ages onwards, and many distinguished medieval thinkers, such as Boethius, Siger of Brabant and Roger Bacon[78], had been strongly influenced by Averroes's radical Aristotelianism. This tradition of Aristotelianism survived well into the Renaissance.

This already established tradition of Aristotelianism in Padua later merged with philological studies of original Greek texts of Aristotle, and many humanists who partook of this intellectual excavation were either themselves Greek or had been educated by Greeks. Erasmus himself had travelled to Paris, where Janus Lascaris was teaching, and then to Venice in order to learn Greek from Greeks. There were two printing presses in Venice alone that printed books written in Greek.[79] By the sixteenth century, Greek students and professors already had a remarkable presence

[75] Runciman. 1985. p.213

[76] Dialetis et al. 1999. p.48

[77] J.H. Randall. "The Development of Scientific Method in Padua" in the *Journal of the History of Ideas.* Vol. 1/2. 1940, p.181

[78] B.Russell. *A History of Western Philosophy*. New York: Simon & Schuster, 1945. pp.464-5

[79] Runciman. 1985. p.211-212

in Padua.[80] While two eminent representatives of Renaissance Platonism had been Greek, Plethon and Bessarion, mainstream Greek thought, as condoned by the Patriarchate had been a combination of Aristotle and the teachings of the Orthodox Church fathers. Still others, like Lascaris, a member of a Byzantine noble family[81], influenced French neo-Platonism of the 16th century, through linguistic training, editorial help in preparing printed editions of classical texts. Demetrios Dukas from Venetian Greece took part in the preparation of the well known Polyglot Bible.[82] Other Greeks in exile trained classical scholars and orientalists in the Greek language as late as the 16th century.[83]

The College of St.Athanasios was founded in 1577 in Rome. Aristotelian philosophy, along with the teachings of the Orthodox Church constituted the curriculum and the school aimed to educate the Greeks of the Ottoman Empire.[84] While most future Greek scholars graduated from this school, Padua retained its eminence and one could also find Greek students in universities north of the Alps who might have acquired their training in modern philosophy, if they studied in France, Holland or England.[85]

Moreover, Greeks often played intermediary roles, either as interpreters or as liaisons in book and manuscript exchanges. In the hey-day of the Republic of Letters, which corresponds to the Tulip Age in the Ottoman Empire, one could often find mixed intellectual milieus, such as the one of Es'ad Yanyevî(d.1731).[86] Es'ad Efendi was a protégé of Dimitri Cantemir, the Moldavian prince, but also a famous musician and historian, and friends with Nicolas Mavrocordato, a former dragoman at the Porte and the Phanariot prince of Wallachia who was known as a lover of arts & letters and who had significantly contributed to philology and humanistic studies in Europe both

[80] de Ridder-Symoens, p.430, Runciman.1985 . 221-222

[81] R. Pfeiffer. *History of classical scholarship : from 1300 to 1850.* Oxford : Clarendon Press, 1999., p.61

[82] ibid., p.65

[83] ibid., p.87

[84] Dialetis et al., p.46

[85] de Ridder-Symoens. p.440

[86] Pippidi. pp.248-249

through his erudition and ideas, as well as the classical texts in his possession(ref.), with Daniel de Fonseca, a Spanish Jew who migrated to the Ottoman Empire and was in the entourage of Mehmet Çelebi in his mission to Paris, and with Chrysanthos Notaras, a member of Byzantine nobility, like many other eminent Greek intellectuals in early modernity, and the patriarch of Jerusalem, and a follower of the philosophy of Democritus. Es'ad was born in Yanya (Ionnina in present day Greece), had a *medrese* education, and had taken additional geometry classes from Müneccimbaşı Mehmed Efendi[87], probably the same person to whom Tezkireci Köse İbrahim presented his translation Duret's astronomical tables (see below), and astronomy classes from another Mehmed Efendi, *müftü* of Tekirdağ. He began teaching in 1691, was later commissioned by Sadrazam Damat İbrahim Paşa to translate Aristotle's Physics from Greek in 1721. He used Ioannis Cotunius's commentary, as well as those of Ibn Rushd and various medieval European commentators for the translation[88]. Es'ad Yanyevî also wrote on theology, translated a lexicon from Persian and also wrote on Aristotle's *Organon.* [89] He became the kadı of Galata in 1725.[90] His career seems to be singularly interesting and both his work and his life demands further study.

Cotunius was from Karaferye (Veria)[91] He had a *licentia docendi* in philosophy and theology from Padua, and had taught there as a Professor of Greek before he established a college for Greek students there in 1653[92], he died in 1658 as the Metropolitan of Salonica.[93] He had written extensively on the Aristotelian corpus on natural philosophy. A certain Greek named Spatroti had received a *berât* for his help

[87] K. Sarıkavak. *XVIII. Yüzyılda Bir Osmanlı Düşünürü: Yanyalı Es'ad Efendi* p.19-20 / M. Kaya "Some Findings on Translations Made in the 18th Century from Greek and Es'ad Efendi's Translation of the Physica" in *Transfer of Modern Science & Technology of the Muslim World.* p.387. / Also see M.İpşirli "Lale Devrinde Teşkil Eden Tercüme Heyetine Dair Bazı Gözlemler" in *Osmanlı İlmi ve Mesleki Cemiyetleri.*

[88] Lohr, pp.724-5

[89] Sarıkavak, pp.33-5

[90] Sarıkavak, P.26

[91] Kaya, p.388.

[92] Lohr, p.724

[93] Kaya, p.388.

to Yanyevî in this translation. [94] It is difficult to characterize Yanyevî's work. Did Yanyevî himself distinguish between the Aristotle as it had been studied in Europe and the Aristotle of the Ottomans? Moreover, if he was characterized as a student of Democritus, an ancient Greek philosopher who is considered an atomist and who had expounded a view of the physical world that was very close to the "pure motion and extension" approach of Descartes, was he interested in Aristotle at all? Unlike Aristotle, he had argued that the physical world lent itself to mathematical study[95] And only in a framework of "natural laws" was physics an *ʿilm*. [96] That he put forth these ideas in what is allegedly a translation of Aristotle I think begs the question of what role Aristotle precisely served in Yanyevî's work. Was Yanyevî Cartesian, was he a "mechanical philosopher"? Considering that many Jesuits residing in Istanbul in the early 18th century would be influenced by Descartes might point to a positive answer. Nevertheless, further inquiry into the Ottoman intellectual circles of the time is necessary to answer these questions.

Chrysanthos Notaras[97], who had started his studies in the Patriarchal Academy later studied in Vienna, Venice and Padua and resided at the Paris Observatory for several months. He was an anti-Copernican, like many other European astronomers of the time. He pointed out that Copernicus's ideas were nothing more than a reproduction of the cosmological model proposed by Aristarchos of Samos, an attitude that saw no more than a truth equivalence between the Aristotelian and the New Science, much like what Seyyid Ahmet Pasa felt when he was once again translating el-Fethiyye into Turkish in mid-19th century.[98]

Indeed, when Dialetis & al. remark that Greek thought and science would best be characterized as "religious humanism... [synthesizing] the teaching of ancient Greeks

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[94] Sarıkavak, pp.26-7. / Kaya, p.390.

[95] Sarıkavak, p.84.

[96] Sarıkavak, P.90

[97] Dialetis et al., p.51

[98] R. Demir & Y. Unat. "Ali Kuşçu ve El-Muhammediyye, El-Fethiyye ve Risale fi Hall Eşkal El Mu'addil li'l-Mesir Adlı Eserlerinin Türk Bilim Tarihindeki Yeri" in *Düşünen Siyaset* 16. 2002, p.248

with the teachings of the Orthodox Church fathers",[99] they were not only qualifying the Greek thought of the 16th through the 18th centuries, but also, perhaps unwittingly, making a claim on the nature of learning in the Ottoman Empire in general. Ottoman scholarship of the era, as exemplified by Es'ad Yanyevi's translation of Aristotle's Physics, or Müteferrika's *Nizamü'l Ümem*, also sufficiently display minds trained for classical scholarship with a religious twist used as a means to evaluate and understand current trends and practices in philosophy and science.

Theophilos Koryladaeas,[100] who was educated in Padua in early 17th century, kept the company of Cremonini, who was a vehement Aristotelian over that of Galileo and carried the organization of teaching of Padua to the Patriarchal academy. Dialetis et al. qualify Koryladaeas's take on Ptolemy as "focused on physical, qualitative description, pointing out the Aristotelian features of Ptolemaic cosmography", reminding us of the *hey'et* tradition prevalent in the Arabic scientific ecumene. Henderson remarks the work of Koryladaeas is an extension of the last two centuries of Byzantine thought, and qualifies it, after Papanoutsos, as scholastic. The differences between the approaches of Dialetis and Henderson is worth remarking, since the former seems to evaluate Koryladaeas's thought on Koryladaeas's own terms, as a reaction to the new science, then prevalent among many Paduans. [101]

Many eminent scientific figures and philosophers at the time had had a humanistic education, had a predilection for ancient thought and literary style, and often balanced the two in their works. Kepler himself, who would finally articulate the planetary theory that would separate the paths of Ptolemaic and modern astronomy, too, was interested in classics and had the desire to study them and incorporate them

[99] Dialetis et al., p.47

[100] Dialetis et al., p.48. / N. Iorga *Byzantium after Byzantium*. Tr. L. Treptow. Portland: Center for Romanian Studies, 2000. p.196

[101] Cesare Cremonini, who was a leading figure of Paduan Aristotelianism in the first half of the 17th century, was a teacher of Koryladaeus. For a short biography and bibliography, see pp.728-729 in C.H.Lohr "Renaissance Latin Aristotelian Commentaries: Authors C" in *Renaissance Quarterly*. Vol.28/4: Studies in the Renaissance Issue. 1975. pp.689-741

into his own works.[102] And what Henderson calls "scholasticism" was actually one of the many faces of early modern humanism.[103] A quick glance at the history of early modern humanism shows that most of the studies and translations, had religious and occasional Pythagorean-hermetic agendas. [104]While humanism came to denote close textual analysis through its development into philology, one may reasonably claim that humanism had its own apparatus of seeking universal truths in ancient texts through means disagreeable to the modern scientific mind.

In the latter half of the 18th century, most Greek scholars then residing in Europe started coming back to Ottoman towns, due to two chief reasons: The economically thriving Greek communities, and the gradual marginalization of classical natural philosophy, by now, supposedly uprooted by mechanical philosophy and the New Science.[105] Indeed the Europe which marginalized classical natural philosophy beyond philology was the one 28 Mehmet Çelebi observes. Surprisingly, the Aristotelian curriculum becomes obsolete[106], after much criticism from Descartes and others from the mid-17th century onwards, only later in the 18th century, and this seems to overlap with increased interaction between various inhabitants of the Ottoman Empire and men of the Republic of Letters, which means that a time gap between the inclusion of modern science in mainstream university teaching in Europe and the introduction of such scientific ideas to the Ottoman Empire practically does not exist. Sonja Brentjes's article on the travellers' accounts of the 17th and 18th centuries additionally suggests that there is a scientific/philosophical dimension to this interaction, beyond the

[102] Anthony Grafton. "Kepler as Reader" in *Journal of the History of Ideas* vol 53/4. 1992, 561-572. p.564

[103] Henderson, p.572. cf. K.E. van Liere "Humanism and Scholasticism in Sixteenth-Century Academe: Five Student Orations from the University of Salamanca" in *Renaissance Quarterly*. Vol.53/1. 2000. 57-107

[104] Avner Ben-Zaken. "The Decade when the Sky Fell and a New Astronomy Arose", delivered at History of Science Society Austin Meeting 2004.; cf. Aydın Sayılı. "Tycho Brahe Sistemi Hakkında XVII. Asır Başlarına Ait Farsça Bir Yazma. *Anatolia*, vol.3. 1958. pp.79-87 for how such aspects do not appear in Turkish scholarship on the History of Science

[105] Dialetis et al. p.50

[106] see for an extensive treatment of Aristotelian education in the 17th century: F.Reif "The Textbook Tradition in Natural Philosophy, 1600-1650" in *Journal of the History of Ideas*, vol.30/1. 1969. pp.17-32

practical aspect, illustrated by the technology and military arts as transferred by Bonneval and de Tott. Under these circumstances, the apparent adherence to ancient and Arabic philosophy in the Ottoman Empire seems even more intriguing, since the predilection for the "classics" or the "ancients" seems not to be out of either a disdain for "European" thought, or religiosity, or backwardness, neither was such predilection confined to the Arabic scientific ecumene, indeed precisely in the 17th century, a period during which *medrese* education falls under great scrutiny by Katip Çelebi and Koçi Bey, there seems to emerge what one may call an Ottoman scientific ecumene, closer to Europe than to the well established Arabic scientific tradition, shared by Greeks, Turks, Arabs and many other South European nationalities alike.

From the mid-18th century onwards, religious humanism seems to play an increasingly peripheral role in Greek scholarship. Iosiopos Misiodax,[107] wrote on Copernicus and the telescope. Moreover, he also demanded a conceptual separation between science and Holy Scripture. Evgenios Voulgaris, a 19th century figure, tried to combine scripture with observation and the New Science, and displayed a predilection for the Tychonian system.[108] Again, the same trend could be followed among the Ottoman Turks, as mid-18th century also marks a turning point in Ottoman scientific activity, as characterized by the mathematical works of Gelenbevi on European mathematics and algorithms, written for the education of engineering students.

Most Greek scholars, like their Muslim Ottoman counterparts, did not specialize[109] in any single field of study. And again, like their Muslim Ottoman counterparts, looked at the new science as knowledge to be acquired, studied and synthesized with traditional learning, rather than as a different business altogether, one which aimed to produce new knowledge and do away with the old. Indeed, the skepticism towards the new science seems well justified, since the new science was based on a fundamental rejection of Aristotle, easily deemed un-scholarly and rash by a humanist. And one could easily conceive the two conflicting attitudes prevalent among the natural philosophers of early modernity, one fed by skepticism with a propensity to do away

[107] Dialetis et al. p.52

[108] Dialetis et al. p.54

[109] Dialetis et al., p.60

with classics, and one fed by humanism with a propensity to gather and preserve and improve upon the ancient learning. Indeed, if Kuhn was right in his understanding of the scientific revolution as the emergence of a new scientific paradigm, one would only wonder how those who did not recognize such a paradigm shift, considering the new science as a scholarly continuation of medieval science, would react to the new science. Naturally, those who did not recognize such a paradigm shift would try to synthesize the New Science with the old, and accepting new science only insofar as it was in harmony with the old. Having a keener appreciation for Aristotelian or Platonic ideas than for the scientific method, or the new mode of knowing based on "natural laws".

3. THE CONTEXTS AND CONSTRUCTIONS OF OTTOMAN ASTRONOMY

3.1. Astronomy in Europe in Early Modernity 1450-1750

This chapter seeks to illustrate the similarities, or rather, the lack of differences between Ottoman and European science in early modernity through looking at the specifics of the development of Copernican astronomy in comparative perspective. Many of the features of Ottoman astronomy, which were characterized as "medieval" and particularly "Islamic" actually were shared by contemporary Europeans throughout the 17th and 18th centuries. While the celebrities of the Scientific Revolution might be absent in the Ottoman Empire, the cultural and intellectual setting, the motives and practices of the sciences, seems strikingly similar when juxtaposed against the sharp contrast Adıvar and subsequent historians of Ottoman science have drawn between Europe and the Ottoman Empire.

Astronomy in Europe, as it was in the Ottoman Empire, was set in a larger context of natural philosophy, mathematics, religion and popular belief. European astronomy, like Arabic astronomy, was a claimant to the Ptolemaic heritage. There is one caveat to this claim, however. European astronomy before the 11th and 12th century translations of Arabic astronomical and astrological works, before the translation of the Almagest from Arabic, and before the arrival of the astrolabe, mostly from Sicily and Spain, had been restricted to timekeeping and qualitative astronomy.[110] Simple timekeeping based on observing the basic course of the sun was performed in the monasteries and beyond that, one would often only find figurative presentations of the celestial order in encyclopaedic works.[111] The mathematical sciences, known as the *quadrivium*, had come back to the educational scene after the translations from

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[110] S.C. McCluskey. *Astronomies and Cultures in Early Medieval Europe.* New York: CUP, 1998. p.171. / H.Hugonnard-Roche. "The influence of Arabic astronomy in the medieval West" in *Encyclopaedia of Arabic Science*. London: Routledge, 1997. pp.284-303. O.Gingerich "The Eye of Heaven", p.141.

[111] McCluskey. p.99, p.127.

Arabic into Latin in the 12th century.[112] Even the logical and linguistic sciences, the *trivium*, could be studied only in part in the early middle ages[113] since the only the letters and religious literature of the Roman world had been preserved in Western Europe,[114] and most Aristotelian sciences in the Middle Ages owed much to Boethius who had translated Aristotle's works on logic in the early 6th century.[115] The Universities, which were corporations of scholars and students as distinguished from the pious endowments that were the *medreses*[116], emerged in the 13th century.[117] And technical training in Ptolemaic astronomy would only emerge in the 14th century Oxford, and would include only simple recitation and some practice with the quadrant and the astrolabe for timekeeping and calendrical purposes.[118]

A geocentric universe[119], with the sun, the moon, the stars and the planets rotating around the earth constituted the prevalent cosmology, and had been preserved from late antiquity. The heavens were composed of seven celestial spheres, which included the five known planets and, the sun and the moon. Beyond these seven spheres was the sphere of fixed stars. In the original "pagan" model from classical and late antiquity the sphere of fixed stars was moved by the prime mover, the source of all motion in the universe. The sphere of fixed stars moved a full circle in the course of a day, whereas the planets revolved around the earth in fixed periods in their orbits, which were considered physically real and made of aether. Moreover, according to

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112 R.Dales *The Scientific Achievement of the Middle Ages.* Philadelphia: University of Pennsylvania Press, [1973] pp.11-13. / Lindberg. Pp. 268-9

113 G. Leff "The Trivium and the Three Philosophies" in Ridder-Symoens 1, p.314.

114 W.A.Wallace *Prelude to Galileo*, Dordrecht : D.Reidel Publishing, 1981. p.4

115 F. Solmsen "Boethius and the History of the Organon" in *The American Journal of Philology*. Vol.65/1. pp.69-74.

116 T.E.Huff. *The Rise of Early Modern Science*. Cambridge : Cambridge University, 1995. p.163.

117 de Ridder-Symoens, p.6: "If one regards the association of teachers and students of various disciplines into a single corporate body as the decisive criterion, then the oldest university would be Paris, dating from 1208." Cf. P.R.McKeon "The Status of the University of Paris as Parens Scientarum" in *Speculum* vol.39/4. 1965 pp.651-675

118 McCluskey, p.193-4.

119 C. Ptolemy. *Almagest*. Pp..10-12 in *Great Books of the Western World vol.16 Ptolemy, Copernicus, Kepler.* Chicago: Encyclopaedia Britannica, 1952.

Aristotle, the universe had always existed and, was in a perpetual motion.[120] The prime mover that was in the original Aristotelian model was absent among the Christians and Muslims and was replaced by a creator who created and commanded the motion, while the sphere of fixed stars remained intact. And the universe had a definite beginning, which was the creation. The heavens were considered, in the Aristotelian, Christian and Muslim cosmologies, incorruptible and perfect.[121]

Ptolemy, an Alexandrian astronomer from the 3rd century A.D., wrote a compendium of mathematical models for the motion of the planets, the sun and the moon that was based on this cosmology, this was his *Mathematical Syntaxis*, better known as the *Almagest* (*Al-Macestî*). In this work, Ptolemy didn't presume to speak of actual physical spheres in the heavens but provided just an intricate mathematical model, consisting of numerous additional circular motions on top of the orbits, that tried to explain the retrograde motion, which by Aristotelian dictum, should have no place in the heavens. Ptolemy's model would explain the orbits, and *save the appearances* of the immutable order of the heavens. Although there was much more than saving the appearances to Ancient Greek astronomy[122], its legacy was associated more with pure mathematical modeling, without any reference to physical reality, among the medieval and early modern Europeans.

This Aristotelian scheme modified and then bolstered by a religious cosmology also had natural-philosophical underpinnings. The cosmos was strictly divided into two main portions, the heavens and the sublunar world. The heavenly bodies, the stars and the planets, moved in perfect circles since circular motion was the property of the sublime element, aether, out of which they were made. Heavier than aether were the four elements, fire, air, earth and water, which intermingled in the sublunar world. The heavier elements moved in straight lines and through their heaviness were attracted downwards to the center of the universe. Earth being the heaviest element, and the element out of which most of Earth was composed, resided at the absolute

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[120] D.C.Lindberg. *The Beginnings of Western Science*. Chicago: UCP, 1992 pp.61-62

[121] ibid, pp.249-50. *Copernican Revolution* pp.91-94, D.Pingree "*ʿilm al-Hay'a*" in *EI*[2], p.1135. , S.H. Nasr. *Science & Civilization in Islam,* 2nd. Ed. P.175

[122] see G.E.R. Lloyd. "Saving the Appearances" in *Classical Quarterly*. Vol.28/1. 1978 pp.202-222 for a succinct account of the various aspects of Greek astronomy

center. That the earth could be in motion was a stark impossibility, not only because it was already in the center, since it was the heaviest, and had no natural tendency to go elsewere, but also because if the earth moved, such motion would be experienced in ways that was not in consonance with common sense. The account Ptolemy gave of why the earth does not move was still valid when Copernicus's heliocentric theory made its debut: If the earth moved, there would always be extremely strong winds and any object thrown straight up would have to fall down elsewhere. Yet, neither was the case. Its incommensurability with the common sense and accepted boundaries of the study of astronomy, in fact, was one of the strongest sentiments against the Copernican model. [123]

In 1543, Nicholas Copernicus, a member of the Catholic Church from Poland, published, after much insistence from a Lutheran mathematician, Rheticus, his *De Revolutionibus Orbium Caelestium* (*On Revolutions of Heavenly Spheres*).[124] In this work he expounded several new ideas that were contrary to the prevalent cosmology described above. One of these was that the sun, not the earth, was at the center of the universe. Another idea he expounded was that the earth was not stationary but had three motions. Earth was rotating around its own axis, around the sun, and was also moving in a cone, a motion necessary to explain the equinoxes. Kuhn believed that Copernicus's work was an answer to a technical crisis in Ptolemaic astronomy that emerged in the 15th century, a problem related to the discrepancy between observation and theory. Many studies, some which will be referred to below, have largely refuted this claim, and Gingerich went so far as to say that the only appeal Copernicus could have was in his cosmological aesthetics.[125] The work of Westman[126] has also done much to show that Copernican ideas were disseminated and accepted in many different ways and for many different purposes, and largely undermined the

[123] *Cop. Rev*. Pp.151-155. p.213-215 in E.Grant "Late Medieval Thought, Copernicus and the Scientific Revolution" in *Journal of the History of Ideas*. Vol.23/2. 1962. pp.197-220

[124] *Cop.Rev*. p.196. R. Westman "Proof, poetics and patronage: Copernicus's preface to De Revolutionibus" p.181. J.R. Ravetz "The Copernican Revolution" in *Companion to the History of Modern Science.* Ed. R.C.Olby, G.N. Cantor, J.R.R. Christie & M.J.S. Hodge. London: Routledge, 1990. p.203

[125] Gingerich. pp.199-200.

[126] see below: "Melanchthon Circle", "Two Cultures or One?" and"Proof, Poetics and Patronage"

idea that the history of the emergence of modern astronomy is monolithic.

Even before it was published, Copernicus, as well as Rheticus, knew that Copernicus's new modek for the universe would be unpalatable to most scholars, not only because it challenged the established view, but also because it was an astronomical work and did not really deal with the physical problems involved in the heliocentric model, since the book was intended specifically for an audience of mathematicians.[127] Osiander, a friend of Rheticus, wrote in the foreword to Copernicus's book regarding the ideas expounded therein:

> "...certain scholars, I have no doubt, are deeply offended and believe that the liberal arts, which were established long ago on a sound basis, should not be thrown into confusion... For these hypotheses need not be true nor even probable."
> "... alongside the ancient hypotheses, which are no more probable, let us permit these new hypotheses also to become known, especially since they are admirable as well as simple and bring with them a huge treasure of very skillful observations." [128]

And for the most part, Copernicus's theory was taken as a mathematical hypothesis and his heliocentric model inspired little interest. One of the reasons was that, like his ancient predecessor Ptolemy, Copernicus was also considered a pure mathematical modeller, and his cosmological claims that bore on the physical constitution of the universe were easily considered out of his league as an astronomer. The mathematical constructions of De Revolutionibus, decidedly simpler than and superior to those of Ptolemy, and thus in line with Ptolemy's own project, piqued greater curiosity and interest than the heliocentric model with which we today associate Copernicus.[129] Indeed "De Revolutionibus was widely read, but it was read in spite of, rather than because of, its strange cosmological hypothesis."[130] Placed side by side with the claims

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[127] *Cop.Rev*. p.143 Gingerich p.164

[128] N.Copernicus *On the Revolution of Heavenly Spheres* in *Ptolemy, Copernicus, Kepler,* pp.505-506

[129] R.Westman "The Melanchthon Circle, Rheticus, and the Wittenberg Interpretation of the Copernican Theory" in *Isis* vol.56/2. 1975. pp.164-193. see pp.166-167. / *Cop.Rev.* p.186

[130] *Cop.Rev*. p.186; cf. J.P.Zetterberg. "Hermetic Geocentricity: John Dee's Celestial Egg" in *Isis* vol.70/3. 1979. pp.385-393. see esp. p.388.

of Westman and Gingerich, Copernicus and his heliocentric theory seem to be little more than a shadow, and what Copernicus actually achieved still remains a topic of heated debate.

The actual process of reception of Copernican astronomy is especially important to this chapter, since a careful study of this process will shed light on certain erroneous interpretations and unreasonable expectations that haunts the history of Ottoman astronomy. As will be discussed later, Ottoman astronomy has been put to a rash and unfounded competition[131] against Copernican astronomy by some historians of Ottoman science, which can be sufficiently dispelled if the context of Copernican astronomy in all its components, of its acceptance and dissemination, is better understood. Copernican astronomy not only caused debates within the circles of most prominent mathematical astronomers, but also among those who were outsiders to this discipline. The geometric models of Copernicus were arguably useful[132] in preparing astronomical tables, but was mostly old news to many who had an acquaintance with Peurbach, Regiomontanus or Ibn al-Shatir.[133] The cosmology expounded by Copernicus also ran counter to the interests of both navigators and astrologers.[134]

Dissemination of scientific ideas is a long and complicated process, even when viewed on purely scientific grounds divorced from the surrounding cultural, religious or intellectual context. In Westman's words: "...there exists an understandable tendency among some historians and philosophers of science to treat a later, well-supported version of a theory as though it were the same account available to its earliest recipients."[135] In the following paragraphs, I will try to sketch the dissemination and

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[131] Adıvar pp.124-5, Demir-Unat p.248, see below, also see E.İhsanoğlu, 1992.

[132] R.Westman "Two Cultures or One?: A Second Look at Kuhn's The Copernican Revolution" in *Isis*. vol.85/1. 1994 79-115. p.106

[133] Nasr p.173, Saliba, pp.254-5, 267-9. The work done on Maragha astronomers has now become especially momentous, since why Copernicus did what he did and what his sources are becoming increasingly pressing questions.

[134] *Cop. Rev.* p.38,p.94. / p.393 in Zetterberg. / P.253 in M. Graubard. "Astrology's Demise and Its Bearing on the Decline and Death of Beliefs" in *Osiris*. vol.13 1958. pp.210-261

[135] Westman, 1975., p.165

acceptance of Copernican astronomy mostly based on the actual content of his works. Later, the reader will find certain cultural and religious elements that further complicated this already extremely long and complicated process. Therein will be discussed various political and religious turmoils that Europe was going through from the 16th century onwards which would make outsiders even more skeptical to Copernican ideas. And indeed, one should be more surprised to find, rather than not to find, any serious treatment of Copernicus in the Ottoman Empire.[136]

The appropriation and acceptance of Copernican astronomy took place through several channels, and no astronomer accepted or used the Copernican model in its entirety.

Erasmus Reinhold composed the astronomical tables known as the *Prutenic Tables* in 1551 based on Copernican mathematical devices, but still maintained the geocentric model. Since the tables prior to this had become outdated, Reinhold's tables became widely used and accepted for astronomical as well as astrological computations. This was the first serious foothold of Copernicus's *De Revolutionibus* in Europe. [137]

Indeed Copernicus's original account for a heliocentric world system was ill supported, and, even as a hypothesis, accepted only by a handful of thinkers, most of whom started to take the Copernican heliocentric study seriously after the comet of 1577.[138] The comet of 1577 proposed a special difficulty to natural philosophers, since it was an extraordinary celestial phenomenon which couldn't be explained within the present Aristotelian framework. The problem was twofold: 1) Comets came into being, which meant that heavens were not incorruptible and were subject to change. 2) Comets did not appear to have circular orbits, which raised the suspicion that heavenly bodies did not necessarily move in circles. The difficulty astronomers and

[136] G. Sarton *The appreciation of ancient and medieval science during the Renaissance : 1450-1600.* 2nd ed. Philadelphia : University of Pennsylvania, 1955. Sarton describes the state of astronomy in Europe until the 17th century as a period of "futile attempts" and "chaos". "In spite of Copernicus' bold departure, the new astronomy is not his nor does it belong to the Renaissance; it was created by Kepler and Galileo in the seventeenth century." pp.162-163

[137] *Cop. Rev.* p.188./ Gingerich, pp.230-232

[138] V.N. Brotons "The Reception of Copernicus in Sixteenth-Century Spain: The Case of Diego de Zuniga" in *Isis* vol.86/1. 1995. pp.52-78. see p.53, nn.2-3

natural philosophers were struggling with as late as mid-17th century was succintly put forth by Edmund Halley in his preface to Isaac Newton's Principia:

> *Now we know what curved path the frightful comets have;*
> *No longer do we marvel at the appearances of a bearded star.*[139]

Comets, according to Aristotle, existed in the upper atmosphere and not in the heavens. Its motion was linear, since it was made up of the four elements, not aether. Tycho Brahe, a late-16th century astronomer, studied the parallax of the comet and discovered that the comet was far above the atmosphere, and indeed, was a celestial event. This did not disturb Tycho, since Tycho was not a keen follower of Aristotle's sharp distinction between the heavens and the sublunar world. He also considered the Copernican model viable, though only in a limited sense. He soon discovered that the tail of the comet always pointed away from the sun, and concluded after making several other observations and calculations that the comet was orbiting around the sun. His calculations and drawings, however, still referenced an immobile earth.[140] The possibility of a celestial body revolving around the sun raised eyebrows among the astronomers and natural philosophers in the 16th century. Tycho himself later formulated the theory of a geocentric universe, but this time, it was only the sun and the moon that rotated around the earth, and the planets rotated around the sun. Tycho's model, as it was based on extensive observations he made in Uraniborg and his model was more rigorously articulated and took into consideration all the corrections he made to the previous data for the motions of the stars, attracted greater attention and was one of the main contenders against Aristotelian astronomy well into the 17th century.[141] His model had the additional virtue of not bringing in the tremendous natural-philosophical, cosmological and cosmographical problem of a mobile earth into the astronomical scene. The problem of calculating the orbits of the comets was to be solved later by Newton.

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[139] Newton, Isaac. The Principia: Mathematical Principles of Natural Philosophy. Tr. I.B.Cohen & A. Whitman. Berkeley, Los Angeles: University of California Press, 1999. P.379

[140] J.R.Christianson "Tycho Brahe's German Treatise on the Comet of 1577: A Study in Science and Politics" in *Isis* vol.70/1. 1979, pp.110-140, see pp.121-122

[141] de Ridder-Symoens, p.592

Copernican astronomy, even when it finally matured in the hands of Kepler in the early 17th century, was still up for debate as late as mid-17th century.[142] Kepler was a student of Maestlin, one of the early followers of Copernicus's heliocentric theory, who published a work called *Stella Nova*.[143] In this, Maestlin treated the appearance of a new star, which had no motion relative to that of the sphere of fixed stars. This, too, constituted a technical crisis – although at a different level - since the entire host of stars was supposed to move together, and moreover, a *new* star also seemed to run contrary to the immutability of the heavens.

Kepler also served as Tycho's assistant at the Uraniborg Observatory.[144] Tycho's observational data remained unpublished until his death and would later be prepared for print by Kepler, under the name of *Rudolphine Tables*. Kepler used this data and formulated a theory that would satisfy the Copernicans as well as some of the Tychonians[145]. His groundbreaking book, which laid out out his model of the heliocentric universe with elliptical orbits, made its debut under the name of *Epitome of Copernican Astronomy*.[146] Kepler calculated the ratio of the elliptical orbits of the planets to be equivalent to the ratio between the five inscribed Platonic solids, which showed his interest in a Platonic-Hermetic view of the world. The heliocentric universe had always appealed to Neo-platonists, and the mathematical aesthetics of the Keplerian model broke ground among the Hermeticists of the 17th century, which included Newton, as well as many others. [147]

The Rudolphine Tables, as useful observational data, were extensively

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[142] *Cop. Rev.* p.228. / Westman, 1994., p. 111. / H.Butterfield *The Origins of Modern Science: 1300-1800*. New York: Macmillan, 1957. p.107

[143] C.Methuen "Maestlin's Teaching of Copernicus: The Evidence of His University Textbook and Disputations" in *Isis* vol.87/2. 1996. pp.230-247 Cop. Rev. p.207, 209

[144] *Cop. Rev.*, p.213 Kepler *Epitome of Copernican Astronomy* in *Ptolemy, Copernicus, Kepler*, pp.850-1

[145] See C.Wilson "Kepler's Derivation of the Elliptical Path" in *Isis*. vol.59/1. 1968. pp.4-25

[146] see Westman, 1994. for a treatment of of the additional stylistic appeal of Kepler's writings.

[147] Shapin, p.59-61. / Gingerich, p.182, 345. / *Cop.Rev.* p.210

distributed.[148]Noel Duret, a minor astronomer(and astrologer) patroned by Richelieu,[149] still operated on a Aristotelian-Ptolemaic scheme, and calculated from the *Rudolphine Tables* the relative positions of the stars and the planets according to the Ptolemaic model. This preference of Duret for the Ptolemaic model over the Copernican, Tychonian or the Keplerian model was only natural. Aristotelian physics, the natural complement of Ptolemaic astronomy, was still being taught in the 17th century in Catholic as well as Protestant Europe.[150] Moreover, the French Jesuits, who were known to provide the best education in Europe around that time, had a special mission to defend the geocentric theory.[151] While Jesuits, among whom were many excellent scientists, albeit of little fame, tried to disprove heliocentric theory on a scientific basis, Riccioli, a Jesuit, published an erudite discussion of the appearances of the stars in which he listed fourteen possible explanations and set them on a truth-equivalence basis. [152]Afterwards the heliocentric theory was studied with great enthusiasm, but nevertheless, remained a hypothesis, since there was no grounds on which one could prove that the earth rotated or revolved. [153]

Newton's Principia tried to articulate a mathematical physics that united the study of the heavens and the earth under a single discipline. A theory of universal gravitation was necessary to underpin the Earth's rotation, since natural philosophy until then had been unable to show why the earth would move around the sun. The Principia would the last link in the chain of the Copernican Revolution, but Newtonians ideas also had a quite long and complicated dissemination process. Newton himself was distressed about the impenetrability of the established notions and lines of

[148] Gingerich, pp.221-222

[149] Ben-Zaken, 2004., p.6

[150] see Reif, 1969. pp.17-32 for an in-depth analysis of the teaching of natural philosophy in the universities

[151] W. Ashworth. "Catholicism and Early Modern Science" in *Science in Europe, 1500-1800.* ed. Malcolm Oster., pp.117-134. Milton Keynes, UK: Palgrave/Open University, 2002. pp.132-133 / A.G.Shelford "Cautious Curiosity: Legacies of a Jesuit Scientific Education in Seventeenth-century France" in *History of Universities* vol. XIX/2 ed. M. Feingold. New York: OUP, 2004. p.100-1: Even late in the 17th century, Jesuits sympathize with Tycho Brahe's approach, which was ultimately geocentric.

[152] ibid. p.131. / Graubard, p.212

[153] Shelford p.109

demarcation between natural philosophy and mathematics, and about the hostile attitude towards mathematical models in natural philosophy prevalent in the late 17th century.[154] Even in the mid-18th century, more than 50 years after the Principia was published, Catholic as well as some Protestant universities displayed, as reflected through the opinions of the professors and through the constitution of the curricula, an "undisguised disdain" for the Newtonian agenda of uniting mathematics and physics.[155]

3.1.1 Astrology and Astronomy in Early Modernity

Astrology is an essentially mathematical practice based on the suppositions of natural philosophy. Here, an explanation of natural philosophy as opposed to the New Science is due. Natural philosophy sought the reasons behind natural phenomena. The causes rather than a description of phenomena was the preoccupation of all natural philosophers. Nature, according to Aristotle, effortlessly rendered the observer the necessary sensory input necessary to proceed to the question of why. In the Renaissance ancient arts and crafts experienced a revitalization. Among these were the occult arts, i.e. arts that dealt with non-manifest qualities of natural bodies, and the Renaissance is as much associated with magic, alchemy and astrology as with anatomy or medicine.[156] The multiplication of the courts that could offer patronage to philosophers and practitioners of various arts naturally led to the rise of astrology and magic, which were one of the desirable services a court philosopher or astronomer could offer throughout early modernity.[157] Behind this natural-magical atmosphere of the Renaissance was also rising an Anti-Aristotelian, Platonic-Hermetic cosmology, but one which addressed the same why questions natural philosophy did, thereby remaining a parallel alternative to Aristotelian natural philosophy.[158] Different from Aristotle, however, was the understanding of nature as a divine and

[154] Shapin, p.120

[155] See Brockliss in de Ridder-Symoens. p.586

[156] P.234 in K.Hutchison. "What Happened to Occult Qualities in the Scientific Revolution?" in *Isis*. vol.73/2. 1982. pp.233-253.

[157] Lindberg. pp. 276,279.

[158] R.G. Collingwood. *The Idea of Nature.* New York: OUP, 1960 [1945]., p.94

self-creative entity which had human qualities, such as love and hate, and attraction and repulsion. The greater nature was the macrocosmos and the human nature the microcosmos. And the questions pertaining to the human world were directly answerable by the events of the macrocosmos.[159]

The beginning of the decline of astrology dates roughly to the end of the 17th century, the time when classical natural philosophy was being replaced by mechanical philosophy, which completely changed not only the explanations and the answers, but also the questions and methods of Aristotelian philosophy. Mechanical philosophy expounded that the world was a machine, designed by God, but the workings of which were understandable as one could understand the workings of a machine, i.e. through observation and mathematical representations.[160] The culmination of this shift in the questions and the methods of answering them may be found in Newton's Principia: The Principia deals with the various mathematical patterns behind motion, hence its title: *Philosophiae Naturalis Principia Mathematica*, The Mathematical Principles of Natural Philosophy. The main bulk of the work deals with how a body moves, and how that motion can be mathematically described and again, mathematically related to other kinds of motion found in other bodies. The General Scholium, or the epilogue to the Principia, is the only part that properly belongs to natural philosophy. Therein Newton tries to articulate why the planets, the sun and the moon move and how this motion influences the earth. His answer, quite unambiguously, is gravity (action at a distance). However, gravity being a non-manifest, i.e. occult, quality, Newton fails to explain what kind of thing gravity is, why it exists and how it originates from the body, at the same time maintaining that gravity is a property of matter and is proportional to the mass of the body.[161]The problem of gravity that Newton deals with at the end of his Principia is the only natural philosophical section of the work, and was the most interesting, and the most debateable part for natural philosophers of his time. A reader today, on the other hand, is most interested his overall mathematical scheme of the universe and his various formulae pertaining to motion and force. This quantification and mathematization of the universe was intimately related to the

[159] ibid., pp.93-96

[160] ibid., p.107

[161] Newton, p.943

removal of the qualities of matter. In his *World or Treatise on Light*, Descartes described matter as pure extension.[162]

According to Descartes, various qualities of matter were directly determined by the shape of the particles out of which they were made. There were no intrinsic qualities of matter, and unlike Newton, the notion of gravity was also missing. The only explanation the world provided to the observer, then, was based on extension, and was ultimately *quantifiable*. There was no symbolic value in anything physical whatsoever. The cosmic symbolism of the houses of the zodiac, of their relations with the four elements or with various minerals and plants was entirely missing from the picture. The language of quantity also removed the question of *why* in natural philosophy and turned it into a question of *what* and *how*. The Cartesian model of the universe, along with its metaphysical and epistemological apparatus, came to be called "mechanical philosophy". Mechanical philosophy didn't conclusively answer the questions that was the driving force behind natural philosophy, rather, it ignored them and in time, rendered them obsolete.

In the setting of natural philosophy, as opposed to mechanical philosophy, which still dominated Europe until the end of the 17th century, astrology seemed to make sense.[163] Astrology, after all, was as much a characteristic of the Scientific Revolution as it was of the Middle Ages and the Renaissance.

> Alchemy, astrology, and other occult sciences continued on much the same path as they had followed in the twelth and thirteenth centuries, and men of note in science and thought still were not above lending a favorable ear or even pen to their claims. The works of Henry Cornelius Agrippa, Porta, and Cardan contain almost no superstition not found in previous works. A Giordano Brunu, an Achillini, a Bodin, a Kepler, a Francis Bacon, a Robert Boyle, all had their little weaknesses in these matters.[164]

Astrology asked and answered questions that the new philosophy was unable to address, and had a universal charm, even for those who were commonly associated

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[162] R. Descartes. *Philosophical Essays and Correspondence*. Ed. R. Ariew. Indianapolis: Hackett, 2000. p.36

[163] Butterfield, pp.99, 101-3

[164] L.Thorndike "The Survival of Mediaeval Intellectual Interests into Early Modern Times" in *Speculum.* vol.2/2 1927. pp.147-159. see p.158

with modern science. Why human beings act the way they do, why seasons and the weather change, why people commit crimes or why they get sick were, and still are, valid questions. Aristotelian cosmology maintained that all motion originated from the prime mover and that the heavens carried that motion down to the Earth. The religious interpretation of this pagan cosmology turned the heavens from the source of causes into a theater of signs from God. Since heavens were incorruptible, the idea that underpinned astrology was a neo-Platonic theory of emanations. As the heavens reflected God's will in the most perfect form, they also took part in carrying through God's bidding.[165] The main problem with astrology was, throughout the ages, about religion. Since this view could, ultimately, lead to the idea that the heavens were actually divine and not created.[166]

While many historians of science have little respect for astrology as part and parcel of the history of astronomy, one is faced with astrological agendas in every step of the development of astronomy in early modernity. The reasons for this are clear: The motion of the immutable heavens influenced all motion on earth. The heavens, due to their impeccable order and perfect motion, commanded the earth that was made up of lesser elements. While this idea was initially associated with the prime mover being the source of all motion, nevertheless, after its disappearance one still finds astrological determinism, now based on a God who resided behind the heavens.[167] The adoration of the heavens would only later be dispelled by a viable physical theory that was valid for both the heavens and the earth, yet that would arrive only with the Principia. Yet, Newton himself was a practicing alchemist, and the notion of force and gravity that he introduced to physics smelled of Hermeticism, since in the Aristotelian terminology forces, for they were not immediately available to the senses, would be an "occult" quality in contradistinction with "manifest" qualities. [168]Newton had

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[165] L. Thorndike "The True Place of Astrology in the History of Science" in *Isis,* vol.46/3. 1955. 273-278

[166] Lindberg, p.276

[167] Lindberg, p.279

[168] *Principia*, p.58. Also see K. Hutchison, 1982. see pp.250-251 for a discussion of Newtonian physics in the Aristotelian context, also see P.M. Rattansi "The Intellectual Origins of the Royal Society" in *Notes and Records of the Royal Society of London*. Vol.23/2.

replaced the study of one type of occult science with another.

Astrology in practice was very similar to medicine. Astrology was not infallible and the excellence of the practitioner was measured not by his command of learned matters, but by the success of his predictions.[169] Astrology had a multitude of uses, both in Europe and in the Ottoman Empire. Judicial astrology, medical astrology were the two eminent fields. Weather forecasts also made use of astrological evidence. The casting of horoscopes was the most contested area over which astrology claimed competence. The simple modern view of astronomy, largely characterized by the heliocentric system of Kepler which featured elliptical orbits, had incorporated the observations of generations of astronomers, thereby making astrological work more accurate, but had also taken away its essential cosmological underpinnings, since heavens were not perfect, nor was the earth the static center of the universe.

On the other hand, in this intermediary phase in the development of modern astronomy, most educated men in the 16th, 17th and even in the 18th century lived in a world where astrology was considered a valid intellectual endeavor, and indeed most of the heroes of the Copernican revolution in astronomy were intimately involved with astrology. There were *chairs* of astrology in the universities of Rome, Bologna and Salamanca in mid-16th century.[170] Melanchthon, an influential interpreter of the Copernican theory was a firm believer in astrology.[171] Tycho himself believed in the merits of astrology and was involved in a polemic with Hemmingsen, a Danish theologian, concerning the validity and the proper sphere of astrology.[172] In Britain as well, one often found that the greatest attacks on astrology were made on religious grounds and not on scientific ones.[173] Kepler, of a Platonic-Hermetic disposition as a

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pp. 129-143, see esp. pp.131-133, for a historical treatment of competing notions of science and scientificity in mid-17th century England

[169] See İzgi, pp.349-351

[170] P. Wright. "Astrology and Science in Seventeenth-Century England" in *Social Studies of Science* vol.5/4. 1975. pp.399-422, see p.403

[171] Christianson, p.114

[172] Wright, p. 404

[173] Wright, p.413

philosopher, himself cast horoscopes for Rudolph II.[174] Duret's Rudolphine Tables included parts on astrology. [175]

The special case of astrology illustrates one of the many pseudo-scientific cross-currents that a triumphal parade approach to the Scientific Revolution and early modern science omits. The case of astrology also illustrates the survival of a so-called "medieval" mode of thinking well into the 17th century. Astrology was a matter of course for many of the scientists that developed the scientific method. When Ottoman science and especially astronomy has been branded as backward, and qualified as an importer of European scientific ideas, a much more crude notion of science in Europe was being used. Much of what we consider as backward in Ottoman science was actually in existence, and even thriving, in Europe around the same time. The vast geography of Europe showed variegated sentiments and theories about nature, and it seems that while the Ottomans weren't exactly in the future-bound train, operated by the likes of Newton, it was nevertheless on the same band-wagon as most of Europe. Certain sentiments shared by Ottomans and Europeans alike show that there is no reason to assume that Ottomans shared more with the Arab scientific ecumene than with the European one. The general shape of both in early modernity seems to be the one and the same thing.

3.2 Astronomy in the Arab Scientific Ecumene in Early Modernity 1450-1750

Like all natural sciences, astronomy too, is considered a natural part of the Islamic civilization. Although the *akli/nakli* distinction, synonymous with the foreign/Islamic distinction, leads us to ask whether astronomy and astrology were ever integral to the culture of the Arabs and the Ottomans, we may assume by the number of debates on astrology extending from the Abbasid period into the 17th century Ottoman Empire that astrology had become part of the culture. Sayılı also remarks that the observatory, as we know it, is the fruit of the Islamic civilization.[176] Likewise, the *hey'et*

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[174] S.J.Rabin "Kepler's Attitude Toward Pico and the Anti-Astrology Polemic" in *Renaissance Quarterly* vol.50/3. 1997. pp.750-770. p.759

[175] Ben-Zaken, 2004., pp.6-7

[176] *Obs.Isl.*, p.5

corpus produced by Arab astronomers had also been quite comprehensively translated to Latin and in turn, had influenced early modern European astronomy. The claim that Islam itself would not fall under the influence of what it exported to Europe proposes a difficulty, and perhaps even a paradox.

Ignaz Goldziher, whose work has been severely criticized both by Saliba and by Gutas has portrayed the distinction between Islamic and foreign sciences to be quite sharp, and therefore the Islamic civilization to be quite inhospitable to the exact sciences.[177] Despite being generally untenable, Goldziher's perception of Arabic science wasn't entirely unjustified. Pines maintains that most of the early proponents of Greek science were more interested in the practical and the useful sciences such as alchemy, medicine and astrology, and considered these to be the "fruit" of science. Someone called a philosopher in the 12th century would usually be a practitioner of the occult arts and not a philosopher in the modern sense of the term.[178] From the 9th to 11th centuries, it seems that the attitudes towards Greek sciences varied from admiration to hostility because such sciences did not provide an unambiguous benefit to the Islamic community. Certain aspects, such as optics and astronomy, were easily subsumed under a commendable tradition of learning, but still other aspects of ancient learning had led to occultism. [179]Astronomy as a branch of mathematical sciences was allowed and supported, even by Ghazali.[180] In line with this attitude, all eminent Muslim philosophers, such as al-Farabi and Ibn Sina, until al-Razi in the 13th century attacked astrology on philosophical as well as religious grounds.[181] Al-Razi's

[177] see I.Goldziher "Stellung der Alten Islamischen Orthodoxie zu den Antiken Wissenschaften" in *Abhandlungen der Akademie der Wissenschaften.* Vol.8 1916, reference taken from Saliba p.54, f.4

[178] S.Pines "What Was Original in Arabic Science?" in *The Collected Works of Schlomo Pines.* Vol.3. Jerusalem: Magnes Press, 1986, p.329

[179]Ibn Sina considers Astronomy in two parts zîcât and takâvim, and considers the branches of Physics (*ʿilm-i tabiyye*) to be: Astrology, Physiognomy, Interpretation of Dreams, Talismans, and *al-Kimiya* (see A.G. Kapp "Arabische Übersetzer und Kommentatoren Euklids" in *Islamic Mathematics and Astronomy*, vol.19 pp.8-122 see, p.86-88)

[180] Saliba, 1994., p.55

[181] Saliba, 1994., p.56

acceptance of astrology related to his overall attitude towards the sciences which were clearly anti-Aristotelian. He was an adherent of experimental, and occult, science, by which we are reminded of alchemy and medicine by considering the time-frame and the intellectual context, and believed in the progress of science through the accumulation of data.[182]

While astrology has often been blamed either as an irreligious practice[183], or still not as a natural science at all[184], it has nevertheless established itself among both the Arabs and the Europeans as a useful science. Views on astronomy, due to Quranic precedent, and due to the favorable opinion of eminent philosophers in Islam have been markedly positive.[185] While many thinkers have sought to separate these two, since astrology sometimes claims to reveal the unknowable, they have been interlinked in practice, especially in early modern Europe and the Ottoman Empire.

The standard opinion maintained by many scholars of Arabic science reflects how rare scientific development has been after the 12th century, however Saliba has also pushed the debate as far as the 17th century, since even then Arabic *hey'et* tradition seems to be thriving.[186] Notwithstanding this general claim, astronomy and astrology, due to their seeming significance to people's daily religious and worldy affairs, have been important to Arabic civilization as an activity.[187] Although the Ottoman Empire might be lacking in producing geniuses of science that contributed to the progress of

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182 Pines, pp.340-341

183 *Obs.Isl.*, p.21

184 on the classification of the sciences by Ikhwan al-Safa, see Rosenthal,1975. p.55-58, also see *Muqaddimah*. pp. 55-58

185 *Obs.Isl.,* p.21

186 Saliba, 1994. p.283: Mirim Çelebi also contributed to the lunar model /p.284 -5: Giyath al-Din al-Shirazi (d.1542/3), from Persia, also wrote two critiques of the Ptolemaic model. / p.285-6: Ghars al-Din al-Halabi (d.1563) also wrote a work critical of the Ptolemaic heritage, and voiced doubts concerning the eccenters. / p.286-7: Baha al-Din al-'Amili also wrote a compendium of astronomy / p.288: Sadr al-Din Sadiq al-Husaini (d.1622) who wrote on the Mercury and the Moon and claims that his theory is at least equivalent to those which have been expounded by others/ p.289: Citing the existence of such works, Saliba claims might extend the debate into the 17th century.

science in the world, it nevertheless shared the same intellectual and cultural context with the greater part of Europe in several senses. Ideas and cosmological models of medieval Arab thinkers were highly credited in both the Ottoman Empire and in Europe. Moreover, the basic intellectual outlook, characterized by Aristotelianism in natural philosophy and by the liberal arts in education, was also shared by the two. The practices of astronomy, the observational methods and instruments, as well as court astrology and various technical debates displayed enough similarities between the two regions to balance out the differences. Astronomy as an activity was not too different in most of Europe and in the Ottoman Empire.

The history of Arabic astronomy is a vast field of which we still know quite little despite the efforts of generations of scholars who have contributed to the development of that field, such as E. Wiedemann, H. Suter, A. Sayili, E.S. Kennedy, D. Pingree, D. King, G. Saliba and J. Ragep. In comparative perspective the earlier part of Islamic astronomy, up to the Maragha School in the 13th century, has been much better studied than the period following the 13th century. This owes to the fact that many of the earlier orientalists focused, following the torch theory of science, more on pre-12th century astronomy. Most scholarship on the contribution of the Maragha school to astronomy, and astronomy in general after the translation activity in Spain in general postdates late 1950's.[188] In the last few decades, Nasr al-Dîn Tûsi(d.1261) has received special attention and has initiated a inquiry into the situation and influence of Arabic science in the West after the 12th century. Saliba and Ragep as well as others have also focused their attention on post-13th century Arabic astronomy and have published on figures whose prominence is still under discussion such as al-Khafri, al-Kashi, Ulûğ Bey, Ali Kuşçu and al-Shatir recently.

While the relative lack of knowledge on post-13th century Arabic astronomy poses a problem in the historical and comparative study of Arabic science in general, the problem concerns the history of Ottoman science and astronomy in particular, due to the obvious fact that most of the Arab lands were under Ottoman rule after the early 16th century, and contacts with the rest of the Mediterranean basin and the Ottomans were rather frequent. In the light of this aforementioned state of scholarship, a short

[188] Gingerich, p.141.

exegesis of the history of Arabic astronomy is due.

The history of Arabic astronomy is often narrated as beginning in the 8th and the 9th centuries with the translation movement under the Abbasid Caliphs.[189] Others, such as D. Pingree[190] and O. Neugebauer[191] have offered alternative routes of transmission of ideas, theories and data for Arabic as well as Hellenic science. Persian and Indian influences, and even older Egyptian and Babylonian influences also need to be examined. While such claims as argued by Pingree and Neugebauer have the utmost importance for the study of Hellenic and of early Arabic astronomy, the eminence of Aristotle in the later centuries as well as the subsumption of the Persian scientific ecumene into Arabic science, one can, for practical purposes, adopt the standard account that associates Arabic science with Greek Science. Moreover, the very same variety of influences made their way into Europe, both through indigenous channels and through the translation movement that began in 12th century Spain and survived well into the 17th century.[192]

Arabic astronomy, like its European counterpart, inherits several elements of Greek astronomy. Ptolemy's Almagest plays a rather prominent role, and as late as the 16th century, Ptolemaic heritage of mathematical astronomy seems to be venerated and

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189 See D. Gutas. "The Study of Arabic Philosophy in the Twentieth Century" in *BJMES*, 29. 2002.

190 D. Pingree "Astronomy and Astrology in India and Iran" in Isis vol.54/2, 1963

191 O.Neugebauer "The History of Ancient Astronomy Problems and Methods" in Journal of Near Eastern Studies. Vol.4/1. 1945. pp.1-38. see esp. pp.22,25.

192 see p.368 Ramsay Wright "Über Die Schrift "Astronomica Quaedam" von Greaves. in *Islamic Mathematics and Astronomy*. Greaves had a 15th century commentary on Zijj-i Ilkhani in Islamic Mathematics and Astronomy, vol.55. p.8-10. / Tûsî's geometry, what it borrowed from Khayyam, also led the way to the first non-Euclidean geometry, and influenced Girolamo Saccheri in 1733 in David Eugene Smith. "Euclid, Omar Khayyâm, and Saccheri" 1935 pp.1-7 in *ibid.* vol.19 / p.205 p.211 "Histoire de L'Astronomie du Moyen Age par M.Delambre" (pr.1819) p.25, p.31 in the same volume: John Greaves had extensively studied and translated Zijj-i Ulugh Beg (Persian and Latin) / al-Farghani printed in Nüremberg in 1537 and Paris in 1546. Then also printed in Ansterdam in 1669 p.17-18 in Farghani(see above) /Farghani makes a summary of Ptolemy under the title of *Kitâb Cevâmi ʿilm el-nücum ve'l Usûl el-Harekât*. This book is also known as Elements of Astronomy is mentioned in Nasr p.169 / F.J.Carmody "Regiomontanus' Notes on al-Bitruji's Astronomy" in *Isis* vol.42/2. 1951. pp.121-130, C.H. Haskins "The Reception of Arabic Science in England" in *The English Historical Review* vol.30/117. 1915. pp.56-69 etc.

carefully studied.[193] The main line of differentiation within the tradition of Arabic astronomy is between *hey'et* and *zîc*.[194] *ʿİlm-i Hey'et* deals mainly with mathematical constructions -- hence its meaning: the "configuration" of the heavens - is a sub-branch of *hendese* (geometry) and proposes mathematical accounts and proofs of celestial motion. This is very similar to the mathematical modelling with which European astronomers were charged in the Middle Ages and Early Modernity. *ʿİlm-i Zîcat*, the science of composing astronomical catalogues of the motions and appearances of the stars and planets, was quite adifferent endeavor than *hey'et*. *Zîc*es were composed exclusively in observatories, while *hey'et* books were written by mathematicians and without resort to any additional observation. The *hey'et* tradition differed from the Greek matematical astronomy tradition in one significant manner. Ptolemy, in constructing his model, remained quiet about the relationship between the physicality of heavenly spheres and the equant, a mathematical construct claiming a virtual center for an eccentric orbit that passed through the physical sphere if uniform circular motion was to be accepted, (thereby necessarily shattering it) whereas the Arabic astronomers, beginning with al-Haytham, had remarked the inconsistency between Ptolemy and Aristotle. Moreover, while most *hey'et*, despite the fact that Maragha school prepared the mathematical apparatus for a heliocentric system, operates on a geocentric system, *zîc*es, being based on mostly observational evidence were universally useful under many cosmological doctrines with minimal technical adjustment, including the heliocentric theory. For this reason, the astronomers of the Arabic scientific ecumene were driven by tradition to eliminate such inconsistencies, yielding better mathematical models, which would later influence and be improved upon by Regiomontanus and Copernicus in Europe. A list of the problems in the Ptolemaic model that occupied Arab astronomers have been conveniently listed by Saliba in a short article.[195]

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[193] Taşköprüzâde, p.413, Nev'i p.141

[194] for a critical assessment of this distinction, see G. Saliba "Arabic versus Greek Astronomy: A Debate Over the Foundations of Science" in *Perspectives on Science*. Vol.8/4. 2000. pp.328-341

[195]See G. Saliba. "Arabic Planetary Theories after the Eleventh Century AD," *Encyclopedia of the history of Arabic science*. Vol.3 ed. by Roshdi Rashed in collaboration with Régis Morelon. London: Routledge, 1996.

Al-Mamun, the chief patron of Syriac-to-Arabic translation movement, also initiated the tradition of founding observatories.[196] Under Al-Mamun's patronage Shamasiyya and Qasiyun observatories were founded. This also initiated a tradition of observational astronomy distinct from, but also side-by-side with, mathematical/theoretical astronomy among Muslim astronomers. While Bayt al-Hikma, which antedates Shamasiyya, played a crucial role in the advancement of scholarly and philosophical work, from very early onwards, a clear institutional distinction was made between the practical and the theoretical aspects of astronomy through the establishment of Shamasiyya.[197] In these observatories Ptolemaic instruments were used, which clearly shows the influence of Greek astronomy, yet Persian and Indian influence is also visible[198], and the word *zîc*, used for astronomical tables, "itself betrays Persian influence."[199] Abu Ma'shar and al-Khwarazmi were the prominent astronomers who have contributed significantly to observational as well as theoretical astronomy in its outset in the Islamic civilization. Thabit ibn-Qurra, who is associated with the translation movement, also is known to have written on astronomy, but his works were more mathematical, while the work of another Sabean, Al-Battani were on both mathematical and observational astronomy.[200]

After these first generation scholars of Arabic astronomy, come al-Battani Abu'l Wafa, Al-Bitruji, Al-Farabi, Ibn Yunus, Ibn al-Haytham, Ibn Sina and Al-Biruni whose works, among them the astronomical and mathematical ones being the most popular, were translated into Latin in the 12th century Spain and, widely known and studied in Europe long after the 12th century. Abu Ma'shar's astrological works were translated

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[196] *Obs. Isl.*, p.51

[197] *Obs. Isl.,* p.54

[198] *Obs. Isl.*, pp.71,79,80

[199] *Obs. Isl.*, p.80 / also see D. Pingree "The Greek Influence on Early Islamic Mathematical History" in *Journal of American Oriental Society* Vol.93/1 1973, pp.32-43 for an extensive treatment of the "Ptolematicization"/Hellenization of Arabic theoretical astronomy, especially after the latter half of the 9th century

[200] S.H. Nasr. p.99, *Obs.Isl.* p.96, F.J.Carmody "Notes on the Astronomical Works of Thabit ibn Qurra" in *Isis* Vol.46/3 1955 pp.235-242

along with the astronomical works of the aforementioned authors.[201] While their contributions have been significant to the history of astronomy, their work was later built upon by the scholars in Maragha and Samarqand, and their influence on Ottoman astronomy has been indirect, through the works written in the 13th-15th centuries. For this reason, their work will not be treated in this chapter.

3.2.1 Marâgha School

The Maragha Observatory, as an observatory, has been of interest to a number of scholars, including Willy Hartner[202] and Aydın Sayılı.[203] Fuad Köprülü has also written on the architecture and the historical background of the observatory. Maragha is considered the greatest observatory in Islam[204], and marks the zenith of Islamic astronomy by many. Later astronomers, including the Samarqand school and others, borrowed from both the hay ‘a texts and the *zîc*es written at Maragha. In respect to Ottoman astronomy, the hay ‘a texts written at Maragha and the philosophical writings of Nasir al-Dîn Tûsi carry more weight, both in Europe and in the Ottoman Empire, than the *Zîc-i İlhânî* prepared at the observatory, since *Zîc-i Ulûğ Bey*, and not *Zîc-i İlhânî*, was utilized by practitioners of astronomy in the Ottoman Empire until European astronomical tables were introduced in the 17th century.[205] Although Taqî al-Dîn, too, had an observatory, the brevity of its life prevented the replacement of *Zîc-i*

[201] J.B. Korolec “Islam Felsefesinin Krakovi Üniversitesi’nde Ele Alınışı” pp.131-145. in *Islam Felsefesinin Avrupa’ya Girişi* ed. Charles E. Butterworth & Blake A. Kessel, tr. Ömer Mahir Alper. İstanbul:Ayışığı Kitapları, 2001. orig. *The Introduction of Arabic Philosophy into Europe*, Leiden:E.J.Brill, 1994. / C. Burnett “The Coherence of the Arabic-Latin Translation Program in Toledo in the Twelfth Century” in *Science in Context* vol.4/1-2. 2001. pp.249-288, see esp. pp.251, p.258-260, p.265. / pp.478-479, pp.482, C.H. Haskins “Arabic Science in Western Europe” in Isis vol.7/3. 1925. pp. 478-485. / M.Schramm “Frederick II of Hohenstaufen and Arabic Science” in Science in Context. Vol.14/1-2. 2001. pp.289-312. see esp. pp.295-299 and 302-307

[202] p.184.W. Hartner “The Astronomical Instruments of Cha-Ma-Lu-Ting, Their Identification, and Their Relations to the Instruments of the Observatory of Maragha” in Isis Vol.41/2. 1950. pp.184-194

[203] See *Obs. Isl.*

[204] *Obs. Isl.*, p.189

[205] Nasr, p.175. also see pp.268, 272 in Lindberg

Ulûğ Bey. The observational work at Marâgha influenced Europe often indirectly and often in conjunction with the work done at Samarqand.

The observatory itself is one of the largest and the best funded observatories in the Arabic scientific ecumene. There are a number of other peculiarities that should be mentioned briefly. As Ilkhanid armies conquered much of Western Asia, they also brought with them elements of Chinese civilization which made the interaction at Maragha a unique historical possibility. Kublai, the Emperor of China and Hulagu, the Ilkhanid ruler, were brothers and there is evidence that the two collaborated in advancing the arts and sciences in their respective domains. While the observatory was built by Nasir al-Din Tusi, there was also a Chinese astronomer who specialized in instrument construction, named Cha-Ma-Lu-Ting, whose origin is not precisely known,[206] and who contributed to the construction of the observatory and Maragha and also introduced Arabic instruments to China.[207] The observatory at Maragha also employed other Chinese astronomers.[208]

Unlike the smaller observatories in the earlier periods, this one had an astrological agenda,[209] and did not remain restricted to observing the sun and the moon for time-keeping and geographical purposes. This is true of the Samarqand Observatory as well, and without doubt, also of the Istanbul Observatory. As the advancement of the experimental sciences went hand in hand with alchemy, the advancement of observational astronomy went hand in hand with astrology. And often, one finds the two practiced together. Since the occult sciences in the Ottoman Empire have not been studied, it is difficult to determine in what ways the astrology and the alchemy of Maragha influenced the Ottoman practitioners.

There were two important mathematical models that were developed by the

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[206] *Obs. Isl.* 191

[207] p.184.W. Hartner "The Astronomical Instruments of Cha-Ma-Lu-Ting, Their Identification, and Their Relations to the Instruments of the Observatory of Maragha" in *Isis* Vol.41/2. 1950. pp.184-194

[208] Nasr,1987. P.81

[209] *Obs. Isl.* 193, see Nasr p.175

astronomers at the observatory at Maragha. One of them was the Urdi lemma[210],(which was about the angles of a quadrilateral and had been discovered by Urdi, an astronomer in Maragha) and the other, the Tusi couple(which was a mathematical tool that could explain through circular motio why some planets seemed to move in straight lines .[211] These geometric devices in combination constituted the necessary framework for the heliocentric astronomy of Copernicus.[212] As it has been mentioned above, there had always been skepticism among Arab astronomers towards Ptolemy, but in general, Ptolemy had always set the parameters for the study of astronomy, Urdi was the first to bring the first serious innovation to Ptolemaic astronomy, although he was dubious of his alternative until very late in his career: Speaking of the new models, he said in his *Kitâb al-Hay'a:*

> When I saw this result, I hesitated for a long time to include it in this book of mine, for it varies greatly from what is known to people. But then I thought of including it for I became certain of the validity of the method by which I achieved it.[213]

And like the various innovators of Ptolemaic astronomy, he was aware of the development in the Ptolemaic paradigm he was bringing about:

> No one came after him [i.e. Ptolemy] to complete this Art in a correct fashion. And none of the moderns [muta'akhkhirîn] to his work or deleted anything from it, but rather they all followed him. There were some though, such as Abû 'Alî b. al-Haytham and Ibn Aflah al-Maghribî, who raised doubts; but they produced nothing more than doubts.[214]

Certain problems that arose in the Ptolemaic astronomy, as those pertaining to the orbits of Venus and Mercury, which were problematic due to the fact that their orbits were between the Earth and the Sun. The solution to these problems were essential to

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[210] G.Saliba "Persian scientists in the Islamic world: astronomy from Maragha to Samarqand" in *Persian Presence in the Islamic World*. ed. R.G. Hovannisian and G. Sabagh. New York : Cambridge University Press, 1998. p.133

[211] ibid. p.136

[212] Saliba, 1994. pp.267-268: The glory of Copernican astronomy was considered to be its abandoning the equant, but research on Maragha school has shown that Copernicus had little claim to credit beyond heliocentricity. P.266:Since helicentric model required a simple reversal of the vector connecting the sun to the earth while leaving everything else practically intact.

[213] G.Saliba "The First Non-Ptolemaic Astronomy at the Maraghah School" in *Isis* vol.70/4. 1979. 571-576, p.575

[214] ibid, p.575

harmonizing the physicality of the heavenly spheres and their mathematical models. And the models proposed, especially by Tusi, along with the various commentaries on them, such as that of Kuşçu and Khafri, constituted the apogee of geocentric astronomy.[215] The mathematical models were later found in the two important astronomers in the history of Ptolemaic astronomy in early Modern Europe, Regiomontanus and Peurbach, who lrepeated the models. And Peurbach's *Theoricae Novae Planetarum* was an update on the medieval astronomical textbook written by Gerard of Cremona, and had later repeated these models produced at Maragha, and remained popular in Europe until mid-17th century. The theory of the motions of the moon was also identical to the model used by Tusi.[216] Much of mainstream Ottoman astronomy, as well as European astronomy, until the 17th century remained Ptolemaic *a la* Maragha.

Likewise *Şerh el-Mulahhas fi'l-Hey'et*, a commentary written by Kadızâde-i Rûmî, and later updated by Bircandî, which incorporated the mathematical tools discovered in Maragha, remained the most popular astronomy book in the Ottoman Empire until the 19th century, and was printed in Lucknow, Delhi and Istanbul after 1850.[217] The second most popular book in the *hey'et* tradition was Ali Kuşçu's *İlm-i Hey'et*, which likewise reflected the apogee of geocentric astronomy, being based on the discoveries at Maragha.[218] The work done at Maragha defined the new Ptolemaic astronomy. It was by the Maragha school that Ptolemaic astronomy was more or less perfected, and dare I say could very well constitute the foundations of the apparent technical resistance of the Ottomans against Copernican astronomy, since cosmographically and mathematically, Copernican astronomy in its original form had little advantage to

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[215] Saliba p.282, E.S.Kennedy "The heritage of Ulugh Beg" pp.97-111 in *Science in Islamic Civilization.* Istanbul:IRCICA,2000, Nasr p.174,

[216] E.J.Aiton "Peurbach's Theoricae Novae Planetarum: A Translation with Comentary" in *Osiris, 2nd series*. vol.3. 1987 pp. 4-43, see esp. p.7, 42

[217] *Osmanlı Astronomi Literatürü Tarihi* , ed. E.İhsanoğlu & al. See Pp.CXXXII for the number of extant manuscripts and commentaries, p.101 for Bircandi's commentary. See esp. p. 188 in Beitrage zur geschichte der mathematik und astronomie im Islam. Frankfurt : Institut für Geschichte der Arabisch-Islamischen Wissenschaften, 1986 [1922]. for the connection between the works of Tûsî and these

[218] Osm. Ast. p.CXXXIII, p.30, & p.97 for popular commentaries

offer.[219] That the Copernican astronomy was accepted based on its heuristic potential as an alternative to, not an advancement of, Ptolemaic astronomy is becoming an increasingly potent claim for the European case, which also helps explain, to a great extent, why the Ottomans worked through doing scholarship on the Maragha models rather than devising new cosmographical models based on or related to Copernicus's *De Revolutionibus.*

The work done in Maragha has had an impact on both European[220] and Chinese[221] astronomy, yet it influenced more than one aspect of Ottoman astronomy. Tûsi's version of Euclid's Elements was printed in Italy in 1594, upon Murad III's *berât* of 1588, authorizing the sale of this work in the Ottoman lands, by which one may safely assume that the work was quite popular.[222] *Haşiye-i Tecrid*, an exposition of the principles of Muslim Theology, which included natural philosophy was also written by Tûsi and was widely read in the *Haşiye-i Tecrid medrese*s (preparatory *medrese*s where the professors were paid 20-25 akçes per day) and several *şerh*s and *haşiye*s on this work are to be found. [223]

Zîc-i Ilhânî, an astronomical table which corrects and amends to the previous *zîc*es, and has served as the foundation for *Zîc-i Ulûğ Bey*. These *zîc*es were constructed with an eye towards astrological practice, which was the usual use of many *zîc*es, and was superior to the Alphonsine tables, which were used until Kepler's Rudolphine Tables, and were updated by Taqi al-Din only incompletely. The first *zîc* superior to *Zîc-i Ulûğ Bey* was introduced by Tezkireci Köse İbrahim in mid-17th century, and that was Tycho's tables adjusted to Ptolemaic parameters. Nasir al-Din Tûsî, related to or in spite of, depending on the tastes of the reader, was also a court astrologer. Today, it is

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[219] For a summary critique of Kuhn's claim that a technical crisis led to the Copernican Revolution, see R. Griffiths "Was There a Crisis before the Copernican Revolution? A Reappraisal of Gingerich's Criticisms of Kuhn". In *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association 1988.*

[220] E.S. Kennedy "Late Medieval Planetary Theory" in *Isis*. vol.57/3 (1966), pp.365-378, esp. pp.377-378 / see also Ragep, 2001.

[221] *Obs.Isl.*p.207, ff.82

[222] Fück, p.55

[223] Uzunçarşılı, 1988. p.11-12, 25

well known that Copernican astronomy, in terms of the ideas contained in his *De Revolutionibus*, is much less important than the subsequent contributions of Tycho Brahe, Kepler and Galileo. Therefore, there seems to be an unnecessary conflict concerning from whom Copernicus borrowed his idea, whether his work truly is a turning point in Western astronomy and science, or on whether it is the standard bearer of modern astronomy.[224]

[224] See "Batı Bilimi ve Osmanlı Dünyası" below.

4. OTTOMAN ASTRONOMY

4.1 The General Outlook

Now that the distinction between theoretical and observational astronomy is established, Ottoman astronomy may be treated in two separate veins. When *ʿilm-i hey'et* is spoken of, often the branch of geometry which deals with the mathematical descriptions of celestial movement is implied. The popular books on *ʿilm-i hey'et* have already been mentioned. There have been many commentaries on these books, although the commentaries of central importance have been written before the 16th century. A survey of Osmanlı Astronomi Literatürü Tarihi reveals that many other works were either on astronomical instruments, or related to timekeeping. Most such authors aimed their works at the students who anticipated to be *muvakkits*.

Although the fact that most *hey'et* texts following the works of Kadızâde-i Rûmî or Ali Kuşçu were commentaries, a closer reading might truly be worthwhile, since the works of Ragep and Saliba have made extensive use of post-Samarqand texts that were deemed insignificant, precisely because their titles or introductions claimed they were commentaries, and found quite original contributions.[225] *ʿilm-i zijat*, which is observational/computational astronomy was a quite expensive scientific endeavor, which requires major investment on the part of the patron or the practitioner. The only major observatory of the Ottomans was the one built by Takiyüddîn in Istanbul in the second half of the sixteenth century. The lack of a systematic observational astronomy is expected, and besides, the deficiencies in this regard have been made up for in the 17th century, by Tezkireci Köse İbrahim.[226]

Hey'et is pure theory and models the heavens on a macro scale,[227] and as such, it has

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[225] G. Saliba “"Writing the History of Arabic Astronomy: Problems and Differing Perspectives" in *Journal of the American Oriental Society*. vol.116/4. 1996 pp.709-718, see esp. pp. 714-715

[226] *Osm. Ast*. pp.340-5

[227] George Saliba. *A history of Arabic astronomy : planetary theories during the golden age of Islam.* New York : New York University, 1994.

little or no practical use. The *hey'et* tradition seems to have more or less ended in Samarqand, the last representative being Ali Kuşçu, and perhaps Mîrim Çelebi. On the other hand, Saliba has kindled a debate about the possibility of further development, based on manuscripts located in Istanbul.[228] The fact that sources of Ottoman Astronomy have only recently been catalogued in an accessible form therefore suggests that the final word in this field has not yet been said. Even the work of the celebrated Ali Kuşçu has only recently been incorporated in a wider context.[229]

The present state of scholarship shows that Takiyüddîn, who stands out as the most noteworthy Ottoman astronomer after Samarqand, has not contributed to the *hey'et* tradition in any significant way. What he precisely achieved in the observatory is also unknown, therefore there is no reason to assume that he adequately corrected *Zîc*-I *Ulûğ Bey*, which was the designated goal of the observatory. At any rate, he was a prolific writer and and two of his scientific works have recently been published in Turkish translation.

Beyond these figures and a few other celebrities, such as Kadızâde-i Rûmî or Ebûbekir el-Dimaşkî, Ottoman astronomy until 1750 has no other outstanding figures. Even the well-known names have not been exhaustively studied. There are several translations from European astronomical works, but their impact seems minimal. The few native Ottoman sources that have appeared in print so far seem to fail in offering a sufficient picture and periodization of Ottoman astronomy. The modernization paradigm, i.e. that Ottoman astronomy advanced with the introduction of European texts, holds sway because the field is still unexplored. A weak inflow of European astronomy seems to have begun in the early 17th century, which has been called to attention by İhsanoğlu, but the significance of this process is quite obscure.[230] In the first part of

[228] G.Saliba "Persian scientists in the Islamic world: Astronomy from Maragha to Samarqand" *in The Persian Presence in the Islamic World* / see " ʿilm-i felek" in *IAD* / " ʿilm al-hay'a" in *EI²*

[229] see Ragep, 2004. cf. Zekî, [2004] vol.3 pp.124-130 and Demir-Unat, 2002, p.248

[230] Although İhsanoğlu does not discuss the influence Europeans who resided or travelled in the Ottoman Empire might have had on Ottoman astronomy, Brentjes's "On the Relation between the Ottoman Empire and the West European Republic of Letters (17th -18th centuries)" deals with some of the figures which might be of interest. One such person, İsmaël Boulliau[d] (1605-1694) "was a student of Pierre

this chapter, I'll try to chart out some of the main features of Ottoman astronomy, and then, I'll try and evaluate İhsanoğlu's claims regarding the periodization of Ottoman astronomy.

What is known of Ottoman Astronomy is quite little. A bibliographic survey conducted by Yavuz Unat[231] shows that a total sum of 15 books and 88 articles have been written on Ottoman Astronomy. Some of the more substantial studies, such as Âsâr-ı Bâkiye, Osmanlı Astronomi Literatürü Tarihi and The Observatory in Islam constitute the foundation of this chapter. Of the published studies as surveyed by Unat, many treat Ali Kuşçu and Takiyüddîn. These two are the two main celebrities of Ottoman astronomy: The former had a direct impact on European astronomy, and the latter was the founder of the only astronomy.

Ottoman astronomers, like their predecessors from Persian and Arabic lands, found themselves in two related, but only problematically interlinked branches of astronomy. Geometric astronomy, *ʿilm-i haya* in the wider sense, was further subdivided into branches. Some branches dealt with the pure geometry of the heavens - this is what Saliba has called *hey'et* tradition proper. Some dealt with the construction and use of astronomical instruments. Still others developed into specialties of drafting calendars, determining the time and casting horoscopes. The last three taken together developed into two professions, practiced by *muvakkits* and *müneccims.* Saliba also makes a distinction between the practical/astrological astronomy and theoretical astronomy based on the geographical sources of both, the prior being of Persian influence and the latter of Arabic. What he says of Samarqand is especially worthy of note, since it seems to suggest the picture that may also be found in the Ottoman Empire:

Gassendi [(1592-1655) had revived Epicurean atomism, and was an important Catholic natural philosopher], a member of the Parisian erudite circle of the brothers Jacques and Pierre Dupuy, an active astronomer and astrologer, a classicist, and as many of his scholarly colleagues and friends, a (Catholic) priest"(pp.131-2) and had visited the Ottoman Empire in 1646-7. During his visits, had become acquainted with Ottoman educated circles (pp.135-9). Apparently, and interestingly, Boulliau was also one of the first commentators and promulgators of Keplerian astronomy. (C. Wilson, p.23)

[231] "Türk Astronomi Literatürü Tarihi 1923-2004" in *TALID*Vol.2/4 2004

> There is no doubt, therefore, that there was an interest in the *Hey'et* texts, even among those who wrote only Persian *zîc*es, such as *Ulûğ Bey*. The fact that they did not write such texts themselves may simply reflect their temperament and preference for observational astronomy, and the more empirical astrological aspect of that science. They obviously thought that it was a great sign of learning to be well informed on the theoretical issues, too. However, that part of their education seems to have been reserved for the school system, where such theoretical discussions could take place. But they were conducted in Arabic.[232]

4.2 Education and Astronomy

Although, the goal of the *medrese* education was to perpetuate itself and to educate *kadı*s and *müftü*s, in all likelihood, one could also get some training in astronomy there as well.[233] Cevat İzgi mentions 'Alî's *Künhü'l-Ahbâr* which includes a copy of the Mehmed II's *tedris kanunnâmesi* as the earliest evidence of there being instruction in astronomy in the *medrese.*[234] It is by now well known that Ali Kuşçu himself taught astronomy and geometry in Istanbul. Another work showing that *ʿulûm-i riyâziyyah* in general and astronomy in particular must have been studied at some *medrese*s is Kevâkib-i Seb'a, the name of which probably reflects the seven liberal arts, written in 1741[235].

The *quadrivium* in the European universities included astronomy as its third component, and it was studied after and in conjunction with arithmetic and geometry. Likewise, the equivalent of the *quadrivium* in the Arab scientific ecumene was *ʿulûm-i riyâziyye.* The equivalent of the liberal arts in the Ottoman *medrese* was *ʿulûm-ı cüz'iyye(*ancillary sciences), also known as *ʿulûm-ı âliye*(propaedeutic sciences), and included logic, rhetoric (as well as lexicography, lûgat, and composition, nahiv), which corresponded to the *trivium* and geometry (hendese), arithmetic (hesap),

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[232] Saliba, 1998. p. 145

[233] G.Schubring "Recent research on the institutional history of science and its application to Islamic civilization" in *Science in Islamic Civilization* Istanbul:IRCICA,2000. pp.19-37, see esp. p.30

[234] Izgi, p.340 cf. E.İhsanoğlu "Fatih Külliyesi Medresesi Ne Değildi!" in *Osmanlı ve Bilim,* p.76: İhsanoğlu claims that this document is dated from the period between1537-1557.

[235] Izgi, p.342

astronomy (*hey'et*), which corresponded to the *quadrivium.* Philosophy and theology (*kelâm*), and according to Uzunçarşılı, perhaps history and geography as well were studied on top of the liberal arts. The higher discipline was not theology, but *ʿilm-i Kur'an* (Scriptural interpretation), *ʿilm-i hadis* (Science of the sayings of Muhammad) and *ʿilm-i fıkıh* (Islamic law).[236] Since theology and philosophy was placed together with thee ancillary sciences, it is safe to assume that natural philosophy was studied under either of the two headings, although it properly belongs to philosophy, or *ʿilm-i hikmet*, and is considered a theoretical(*nazarî*) and not a moral ('*amelî*) branch. Uzunçarşılı and İzgi are fairly certain that *Eşkâlü't-te'sis* was studied as the geometry textbook.[237] That this book was printed and sold in the Ottoman Empire also seems to verify their claim.

The very same liberal arts tradition seems to be more or less shared by the Ottomans and the Europeans. The *medrese* education in astronomy focused on *hey'et* proper and *ʿilm-i mik'at*(timekeeping), and not on *ʿilm-i zîcât* or *ʿilm-i nücûm*. *Hey'et* was a part of the *medrese* curriculum, and seems to be more or less popular among the educated, but *medrese* education only acquainted the students with basic principles and enunciations and explanations of otherwise proven propositions; and did not often bother going through the Almagest, a knowledge of which was considered the height of astronomical learning by the Ottomans. While Izgi shows that the copying dates and places of *Şerh-i Çağminî* and *Bircandî Haşiyesi* indicate that they must have been studied at *medreses*[238], works relating *ʿilm-i zîcât* or *ʿilm-i nücûm*, the science of horoscope casting, are likewise to be found in copies made mostly by *ʿulemâ*.[239] Included in the *medrese* education until the 19th century was the use of various instruments that help calculate the height of the sun and of the moon, such as the

[236] Uzunçarşılı, p.20.

[237] Uzunçarşılıü p.20. İzgi, pp. 275-6

[238] İzgi, 370-388

[239] pp.367-9. On the other hand, İhsanoğlu's statistical survey of the number of extant manuscripts shows that no work that dealt explicitly with astrology was very popular. On the other hand, Göker remarks that *Zijj-i Ulugh Beg*, also known as *Zic-i Cedîd-i Sultâni*, was made of four main parts, one of which was dedicated to astrology. (Lütfi Göker pp.116-117) There are 29 Persian (Osm. Ast. p. CXXXVIII) + 23 Arabic (ibid. p. CXL) + 17 Arabic (ibid. p.CXLIV) + 12 Arabic (ibid. p. CL) = 81 extant copies of this work, and remarkably, none of them are in Turkish.

astrolabe and the quadrant[240]. This last part of the education aimed to enable the students to determine the prayer time.[241] A 16th century anonymous source also shows that the preparation of calendars, timekeeping and matters pertaining to astrology were the measure of a student's learning.[242] Moreover, what Kâtip Çelebî himself studied was *Şerh-i Çağminî* and *Zîc-i Uluğ Bey*, which reflect *zîc*es, probably for astrological purposes, as well as *hey'et* texts were topics of interest to learned men, although not always in the *medrese* context[243].

Ali Kuşçu's *el-Fethiye* should have been studied in the *medrese* as well.[244] The short review Taşköprüzâde writes in his *Mevz'ûatü'l-'ulûm* on *el-Fethiye*[245] and its commentaries seems to indicate the relative popularity of this work.[246] A close textual analysis of Seyyid Ali Paşa's Turkish translation of *el-Fethiye* has recently been published and might prove useful in a deeper inquiry into Ottoman astronomy. Taşköprüzâde counts *el-Fethiye* among the works that supply no mathematical proofs *"berâhîn-i mezkûrdan tecrîd"*[247], and therefore it is safe to assume that it mainly served as a simple introduction to *hey'et*, perhaps sufficient for the educational agenda of the *medrese*.

Şerh-i Çağminî, the longer title of which was *Şerh el-Mulahhas fi'l Heyet*, has been mentioned earlier. It had been written by Kadızâde-i Rûmî in 1412[248] and was a short textbook exposition of Ptolemaic astronomy. It is a shorter work compared to Kadızâde's commentary on Tûsi's *Tahrîr el-Macestî*, which itself was a commentary on

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[240] Gökmen, Fatin. *Rubu tahtası: nazariyatı ve tersimi.* Ankara : Milli Eğitim Bakanlığı, 1948. pp.V-VI: Fatin Gökmen remarks that the quadrant was actively employed in determining the prayer times throughout the Ottoman centuries, but the last manuscript on how to use the quadrant was written by Gelenbevi. Also see Izgi, p.342.

[241] Izgi, p.356

[242] Izgi, p.343

[243] Izgi, p.340

[244] Uzunçarşılı, p.21

[245] Taşköprüzâde, p.404

[246] also see Adıvar, p.49. f.1

[247] Taşköprüzâde, p.403. also see Saliba, 1998. p.139.

[248] *Osm.Ast.* p.8

the Almagest. Likewise, *Bircandî Haşiyesi* was an annotated commentary on *Şerh el-Mulahhas fi'l Heyet*. In this case, the former work probably served as the primary source and the latter served as a secondary source. While Bircandî had also written on the Almagest, that work of his also seems to be quite unpopular, based on the number of extant manuscripts.[249] These perhaps imply that few students made their way through the various introductory works and instructive manuals for the original texts.

Here, it is important to remind ourselves of the process of learning, teaching and writing in respect to scientific works. While the methods of teaching in the Ottoman *medrese*, presumably made up of lecture, dictation, discussion among the students, as well as memorization, recitation and copying of manuscripts[250], remain unknown to us, many sources[251] indicate that the requirement for an *icâzet* was sufficient knowledge, through memory and intellectual grasp, of the text studied. Usually the name of the *mudarris* is mentioned along with the text studied, [252]and the importance of a good master who would teach the text has been mentioned time and again,[253] as the text itself was not a sufficient basis for proper learning. A similar system would be found, both in Medieval[254] and early modern[255] universities in Europe, but declined as a result of the rise of professional scriptoria serving the students, and was almost

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[249] *Osm.Ast.* p.109

[250] "*madrasa*" in *EI*^{2}, p.1131 / also see G.Makdisi "The Reception of the model of the Islamic scholastic culture in the Christian West" in *Science in Islamic Civilization* Istanbul:IRCICA,2000. pp.1-19

[251] E. Ihsanoğlu. "Ottoman Educational Institutions" in *Ottoman Civilization* vol.1 ed. H.Inalcik & G.Renda. Ankara: Ministry of Culture, 2002. p.357, An undated ferman, presumably from the 16th century, includes the following passage "*... 'ulemâ ve müderrisîn medreselerine sevâlif-i eyyâmdan her pâyede okunagelen kitâbları tâlib-i ʿilmlere tamam müstevfâ okutup birinden tamam mâhir olmayınca birine şuru' itmeyeler. Ol pâyede okunan kitâblaruñ cümlesinde mâhir olduktan sonra ol pâyede ne kadar zaman olduğına ve ne mikdar kitâb okudığına müderrisînden temerrük alıp bir pâyeye dahi müteveccih olup anda dahi bu üslup üzre cehd ve sa'y eyleyeler.*" also see İzgi, p.60

[252] Izgi, pp.87-107

[253] S.H. Nasr. P.73

[254] de Ridder-Symoens vol.1, p.44

[255] de Ridder Symoens vol.2, p.344

entirely abandoned after printing.[256]

The potential causes for this must be invariably linked to the problem of preserving knowledge.[257] The various commentaries served to first preserve, and *only then* improve upon, received knowledge. The *icâzet*s also reflected the image of an uninterrupted chain of transmission of knowledge[258]. Such appeals to lineage could also be found in Europe, where University professors, although in greatly exaggerated ways, traced the knowledge they were about to transmit to ancient Greek or biblical people. The achievement of a great *muderris* would be, therefore, measured by how much of the original knowledge he understood and preserved. Again, these values belonged to religious and philosophical sciences alike.

When Kâtip Çelebi criticized the absence of learned men in philosophy and *riyaziyat*, he was not asking for renewal or reformation in the modes of learning, but he was complaining about how ancient knowledge was being forgotten and how the lineages of learning were being broken.[259] Kâtip Çelebi, probably like anyone else with sufficient means, could find the texts he wished to study, but finding a teacher from whom he could reliably study the text was the real problem.[260] The significance of the teachers seem to have declined after the advent of printing in Europe, since printed works depersonalized the process of learning.[261] The emergence of the likes of

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[256] E. L. Eisenstein. *The Printing Revolution in Early Modern Europe.* New York : Cambridge University Press, 1993. pp.24-25, 124-6.

[257] R. McKitterick. "Books and Sciences before print" in *Books and the sciences in history*. ed. M. Frasca-Spada and N. Jardine. New York : Cambridge University Press, 2000. p.19

[258] Izgi, pp.56-57. / Ben-Zaken notes a peculiarity in Tezkireci's translation.(see below) Ben-Zaken re-analyzes Tezkireci's introduction as reflecting a notion of the history of science which is "centered around a chain of knowledge transmitted from one scholar to another, from one generation to another, smoothly and continuously." Ben-Zaken further argues that there was nothing intrinsically unpalatable to Tezkireci about counting himself part of the chain of these Christian European scholars. This approach seems to go hand in hand with the method of teaching employed at the *medrese*.

[259] Gökyay, Orhan Şaik. *Kâtip Çelebi: Yaşamı, Kişiliği ve Yapıtlarından Seçmeler.* İstanbul: T.C. İş Bankası Kültür Yayınları, 1982. p.253.

[260] ibid. p.253

[261] Eisenstein, p.20

Descartes who aimed to do away with the ancients would only emerge in the mid-17th century in Europe, only after printed books had become widely available, and when critical annotated editions had replaced the teachers.[262]

When the decline of the Ottoman *medreses*, which is quite a standard interpretation today[263], is interlinked with the apparent backwardness of the Ottomans in the sciences, one inevitably overlooks the fact that the motives and methods of the *medrese*s probably would not have shifted, and would have remained loyal to its "scholastic" roots. Therefore the decline of the *medrese* seems to be a *non sequitur* when studied within a framework of the emergence of modern science. The problem of the seeming lack of popularity of modern science among *medrese* graduates, even in the 20th century seems more a philosophical problem of the paradigms of learning and the shape and value of knowledge than a problem with the weakening of the institutions of learning. It is noteworthy that the *medrese* curriculum in the *ʿulûm-i riyâzîyyah* remained relatively unchanged even in the 19th century,[264] and the new learning from Europe made its way into the Empire mainly through new educational institutions, especially through the various technical and military schools.

4.3 Astronomy and Alternative Means of Learning

While *medrese*s were the official institutions of learning, funded by a waqf and thereby providing free education, one also finds other routes that various people have taken that must have lead to a knowledge of astronomy. Among these was private tutoring. The autobiography of Katip Celebi, a scholar with independent means, is known to have taken private lessons from outstanding scholars, although he was never a danismend, a student of senior standing, in his entire life. Khanaqahs and tekkes, sufi lodges, are also known to have provided education in various disciplines, astronomy

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[262] Burke, p.208. F.Robinson. *Islam & the Impact of Print.* pp.236-8

[263] A.Ben-Zaken "Osmanlı İmparatorluğu'nda Bilimsel Faaliyetler" tr. H.Kapu & M.Yavaşi in *Türkler* vol. 11 . ed. Hasan Celal Güzel, Kemal Çiçek, Salim Koca. Ankara : Yeni Türkiye Yayınları , 2002. pp.218-237. Sarıkavak, p.12

[264] Izgi, p.347-348

being one of them.[265]

Education provided in the casting of horoscopes and in calendar drafting remains somewhat of a mystery, since the practice of astronomy and astrology has received little attention. While some universities in Europe were known to teach astrology, the transmission of astrological as well as alchemical knowledge took place through networks and through apprenticeship. For example, how Newton, a self-proclaimed alchemist, was educated in alchemy is still unknown. That the sources of Ottoman astrology also remain unknown perhaps implies that this must have also been the case in the Ottoman Empire. David King mentions a resurgence of astrological literature with the rise of the Ottoman Empire. These works, King claims, were mostly written by astronomers who did not serve as muvakkits, which seems to make Ottoman astrology a particularly curious case compared its neighbors which supposedly belonged to the same scientific ecumene.[266]

There are differences of opinion pertaining to the value and legitimacy of astrology among various alims who lived in the Ottoman Empire, but then again, this was also the case in earlier Arabic and contemporary European contexts. Moreover, seminal books on astrology, such as al-Bari[267] were highly valued. An annotated Turkish version of Al-Mardinî's E*l-Nücûm el-Zâhirât*[268], a famous book on non-horoscopic astrology, was written by Ishak b. Hasan el-Tokâdi (d.1689), and another edition was made by Al-Damanhûri (d.1778)[269]. And one would often find astrology asociated with various other crafts related to metallurgy, mineralogy and alchemy.[270] The Ephemerides Richelianae also included astrological parts.[271] Some texts on astrology in the Ottoman Empire still survive, and the references for a number of them can be

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[265] e.g. see *Osm. Ast.* pp.360-361

[266] King, 1983., p.551

[267] Taşköprüzâde p.363, *Osm. Ast.* p.492

[268] *Osm.Ast.,* p.349

[269] *Osm. Ast.,* 483-4

[270] *Osm Ast*., p.257

[271] A.Ben-Zaken. "The heavens of the sky and the heavens of the heart" in *BJHS,* 37. 2004., p.2

found in Izgi and Ihsanoglu. Their presence indicates that an alternate route of education, probably Sufi or neo-platonist, must have been available to practitioners and proposes an interesting field for further research.

Other alternate routes of learning were also available first through one's family or neighbors. Takiyüddîn, the chief astronomer of the Istanbul Observatory, is worth being mentioned in this regard. Alâeddin Mansûr's account of Takiyüddîn's life indicates that he had learned astronomy from members of his family.[272] Moreover, Takiyüddîn's treatise on clocks had direct relations with Semiz Ali Paşa whom Takiyüddîn had served. In the treasury of Semiz Ali Paşa, he had found various clocks and books on clock-making written by "members of other religions":

> It is difficult to construct such instruments. They need humble skilled technicians, nevertheless, among the first Moslem nations these clocks which were the easiest of all time-measurement instruments, were not taken into consideration. These instruments have come to this country from (Holland), Hungary, France, Germany... While I was in the service of the owner of the victory and glory who deserved all sorts of praises, the minister and its counsellor,... the great Minister, Magesty 'Ali Pacha (1500-1587), God may he be exalted, I reflected on his treasure-house which was prosperious state, had different kinds of instruments. They have several advantages that can not be obtained by astrolabes and quadrants... I searched the skilled technicians of the other religions and gathered their useful fruits from the bunches of the grapes and the branches of the trees... [273]

That education in and practice of astronomy and astrology must not have been limited to the *medrese* is further supported by the presence of non-Muslim astronomers. David the Mathematician, a Jew from Salonica, was in concordance with Takiyüddîn, and probably was employed at the Istanbul Observatory.[274] Moshe ben Yehuda, (fl. 16th c.)also wrote on astronomy.[275] How these individuals were educated, whether in the Ottoman Empire or in Europe, is still unknown.

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[272] Izgi, p.353

[273] S.Tekeli *16. Yüzyılda Osmanlılarda Saat ve Takiyyüdin'in "Mekanik Saat Konstürsiyonuna Dair En Parlak Yıldızlar Adlı Eseri - The Clock in Ottoman Empire in 16th Century and Tagi all Din's "The Brightest Stars for the Construction of the Mechanical Clocks.* Ankara: T.C. Kültür Bakanlığı, 2002. p.140-141

[274] *Obs.Isl.,* p.297

[275] *Osm Ast.,* p.224

Müneccimbaşılık, the post of royal astronomer/astrologer, a uniquely Ottoman institution, also seems to illustrate the alternate routes of education. Dervishes and sheiks who had no formal *medrese* education served at this post.[276] And many of the *müneccimbaşı*s acquired their post through serving at various *kapı*s, rather than through *muvakkitship*. Among the duties of the *müneccimbaşı* were drafting calendars and casting horoscopes.[277] Moreover, the post of *müneccimbaşılık*, was administered by the *Hekimbaşı*, which further implies the independence of practice of astronomy and astrology from the *medrese* context. Chief Astronomer Mehmed Efendi has a curious entry pertaining to his educational background and professional career:

> "He is from Istanbul. Although he kept company with ordinary folk at first, he then honed his skills in *ʿilm-i nücûm* and became the timekeeper of Şehzade Mosque. He then became the Chief Astronomer and died in 1040(1630/31). The calendars he prepared were authoritative and he was a master of his *fenn*."[278]

Mehmed Efendi in all likelihood was a popular practitioner of astrology before he became a timekeeper. Most people who made careers in the fields of astronomy and astrology, as one would expect, derived material benefit from it, and considering the professions that could yield such material benefit, one could easily relate this to the education allegedly provided in the *medrese*.

The function Enderûn must have served in the sciences in the Ottoman Empire is also quite mysterious, since one of the famous polymaths of the 16th century, Nasuh Matrâkî, was educated there and wrote on arithmetic.[279] Assuming that *ʿulûm*-ı riyaziyye formed a coherent whole, it is reasonable to expect that at least some of the astronomers or astrologers could be educated there.

Astronomy was also useful in navigation. Piri Reis mentions the ilm of celestial navigation in conjuntion with astronomy[280] Seydi Ali Reis (d.1563), a famous Ottoman

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276 *Osm Ast.,* p.282, p.281

277 Aydüz, p.165

278 *Sicill-i Osmani*. vol. IV. p1013

279 Adıvar, p.96

280 Piri Reis *Kitab-i Bahriye*. ed. Bulent Ari. Ankara: Undersecretaryship of Navigation, 2002. pp.23-28

Admiral has written quite a number of works on astronomy, among them a Turkish translation of el-Fethiyye, despite the fact that he had no *medrese* education.[281] It seems that all who served as navigators in the Ottoman Empire must have been educated in astronomy insofar as it helped celestial astronomy, but most navigators would not be found getting a *medrese* education at any point in their lives.

4.4 The Istanbul Observatory

The Istanbul Observatory (1577-1580) has been quite well studied, since its foundation constitutes an important event both in the history of the observatory in Islam, and of Ottoman science.[282] It is known to be of similar size with the observatories of Maragha and Samarqand. The instruments used in the Observatory borrowed largely from previous Islamic observatories, but some have been identified as genuine inventions of Takiyüddîn.[283] The instruments used have also been identified to correspond quite precisely to those used by Tycho Brahe.[284] This is a good point of reference for astronomy in Early Modern Europe. Until the discovery of the telescope by Galileo, which was previously invented as a monocular in Northern Europe, had not yet been introduced to mainstream astronomy, and most of the instruments were, as could be expected, computational. The widespread use of the telescope in an observatory setting was popularized in the late 17th century. The Paris Observatory 28 Mehmed Çelebi visited featured a telescope, and as a novelty, piqued Mehmed Çelebi's curiosity.[285] Even then, although the elder Jean Cassini who operated the observatory before his son, Jacques Cassini, was among Galileo's earliest followers, was also known as a keen observer[286]And most of Jacques Cassini's work was based on precise

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281 *Osm.Ast.*, pp.140-145

282 *Obs.Isl.,* p.289, ff.102,103

283 Ünver, 1969. pp.22-23

284 see Sevim Tekeli. "Takiyüddin'in Sidret ül-Müntehasinda Aletler Bahsi" in *Belleten* XXV/15.

285 28 Mehmed Çelebi Kafirlerin Cenneti ed. G.Veinstein, tr. M.A. Erginöz. İstanbul: Ark, 2002 pp.122-5

286 M. Cavazza. "Bologna and the Royal Society in the Seventeenth Century". in *Notes and Records of the Royal Society of London*. Vol.35/2. 1980. see. p.105. A. van Helden. "Telescopes and Authority from Galileo to Cassini." *In Osiris, 2nd series*. vol.9 p.27

astronomical observation and geodesy which means he probably had little to do with Copernican astronomy, like many other Jesuits of the period and what 28 Mehmed Çelebi took with him was data that ran counter to *Ulûğ Bey*'s *zîc*.[287] It was founded by Takiyüddîn, an erstwhile *müneccim*[288], who had demanded that the tables that were available "did not meet the day's needs",[289] by which he probably meant that the predictions made through the *Zîc-i Ulûğ Bey* had grown inaccurate.

Sayili observes that the goal behind the foundation indeed must have been purely astronomical, and not astrological, while its demolition is often associated with *Şeyhülislâm* Sadeddîn's diatribe against astrology[290], as it is known to have been prematurely demolished. This could be approached skeptically, since as a *zîc*, it would most likely benefit practitioners of astronomy and astrology and not those working in the field of *ʿilm-i hey'et.* While the sad story of its demolition, and its function in the contemporary historiography of Ottoman science as a mark of intolerance of the *ʿulemâ*, is of little interest to this chapter.

4.5 *Muvakkits* and *Müneccims*

Professionals of astronomy were either muvakkits or müneccims. *Muvakkits* usually worked at mosques in cooperation with a *muazzin*. Timekeeping had always been a problem in Islam, but the professionalization of timekeeping and the emergence of muvakkits did not come until the 13th century under the Mamluks.[291] Their main duties were determining the prayer times. What a muvakkit needed to know differed in the method he employed, whether he was going to use an astrolabe and a quadrant or a sundial, whether he had timekeeping tables ready at hand or whether he was going to use spherical geometry all factored into the knowledge required for the

[287] *Osm.Ast.,* p.534

[288] Ünver, 1969., p.69

[289] *Obs.Isl.,* p.289

[290] *Obs.Isl,* .p.303

[291] D.A. King "The Astronomy of the Mamluks" in *Isis* vol.74/4 1983. 531-555, p.534

post.[292] Unlike many other offices in the Ottoman Empire, muvakkits were appointed after an examination.[293] The practice with the quadrant and the astrolabe seem in the *medrese*s seems to imply that *medrese*s were partly concerned with preparing their students for this post. However, the scientific competence required for this post was quite different than that required for the *müneccim*. The *muvakkit* practiced *ʿilm-i mik'at* (science of timekeeping) and his sole concern was the motions of the sun. With a table at hand, this task was reduced to measuring the latitude of the sun. However, one could find more distinguished muvakkits at major mosques who had worked with theoretical astronomy, spherical geometry or had constructed sundials. Ibn al-Shatir was such an one and had devised a non-Ptolemaic theory of the motions of the moon[294]. A list of some Ottoman muvakkits with feats of scientific prowess might be found in an article by Süheyl Ünver.[295] Muvakkits, according to Aydüz, survived well into the 19th century until mechanical clocks became popular. [296]

Another task related to timekeeping was the preparation of calendars. This required a set of calculations on the relative positions of the sun and the moon, and made extensive use of *zîc*es. In the Ottoman Empire, the *müneccim*s working for the Sultan had prepared and distributed these calendars.[297] Several references for such calendars may be found in Osmanlı Astronomi Literatürü Tarihi. Naturally, these calendars were much more than just calendars, and included horoscopes. The preparation of horoscopes was a very different and much more complicated task than the calendar itself, since the casting of horoscopes required knowledge of the motions of the

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[292] D.A. King "Religion and Science in Islam I: Technical and Practical Aspects" in *Encyclopaedia of the history of science, technology, and medicine in non-western cultures*. ed. H. Selin. Dordrecht ; Boston : Kluwer Academic, c1997. p. 858

[293] Salim Aydüz "Osmanlı Devleti'nde Müneccimbaşılık" in *Osmanlı Bilimi Araştırmaları* Istanbul: Istanbul University Press, 1995. ,p.189

[294] King, 1983., p.535

[295] S. Ünver "İstanbul Muvakkithaneleri Vazifelerinin İlmi ve Kültürel Değerleri Üzerine in *Proceedings of the International Symposium on the Observatory in Islam.* Pp.44-51 Ed. Muammer Dizer. İstanbul, 1977

[296] Aydüz, p.188

[297] Aydüz, pp.175-176

planets as well. [298]Yet it seems that the two were, at least in the Ottoman case, executed by the same person, since the drafting of calendars was under the monopoly of *müneccimbaşı*s.[299] Although most were *ʿulemâ*, it seems that instruction was offered by the *müneccimbaşı*s and most of the people who occupied the post were related to each other either as students and teachers, or through blood ties.[300] The Sultans seem to have employed müneccims from mid-15th century onwards,[301] but the post of *müneccimbaşı* was instated later in the 16th century. The European astronomical tables were translated either by or for these müneccimbaşıs. While İhsanoğlu maintains that the European tables were translated for practical purposes, such as the preparation of the calendars, it was astrology and not calendar preparation as such that required a full table of the motions of the planets, the sun and the moon. If we consider the uses of astronomy, indeed a full knowledge of both *ʿilm-i hey'et* and *ʿilm-i zîcet* would be utilized only by the *müneccim*s who prepared horoscopes. The connection between astronomy and astrology is clearly marked by this crucial point. The establishment of *Mekteb-i Fenn-i Nücûm*, established in the 19th century in the Ottoman Empire attests to this as well.[302] And it seems that since the post remained intact until the 19th century with the help of translations of *zîc*es from European languages, one might justifiably claim that there was no serious interruption in the work of this institution. Naturally, the *müneccim*s of the palace were only the tip of the iceberg, and one could find many other practitioners, probably practising folk astrology.

4.6 Periodization of Ottoman Astronomy

If one were to periodize astronomy in the Ottoman Empire in the light of the quite meager knowledge we have of it, it would fall roughly into two periods, and that, only problematically: İhsanoğlu claims in his famous article that Ottomans started adopting 'modern' European astronomy from 1660 onwards. This marked the process

[298] Remzi Demir's *Takiyüddîn'de Matematik ve Astronomi* has some information about astrological theory of Takiyüddîn.

[299] Aydüz, p.169

[300] Aydüz, p.165

[301] Aydüz, p.164

[302] Aydüz, p.190

of acknowledging, if not shifting to, the heliocentric model of the universe. Anything prior to 1660, therefore, would belong to Ptolemaic/geocentric astronomy and some of the works after 1660 to Copernical/heliocentric astronomy, yet the number of works on Ptolemaic astronomy either handwritten or printed in the 19th century slights this claim[303]. One could justifiably propose, based on the sources Ihsanoğlu himself uses, that there is no serious distinction between the two periods. It is worth taking a closer look into this article in order to critically assess this attempt at periodization.

In the light of the histories described above, one inevitably asks why and how Copernican astronomy would influence Ottoman astronomers. Ekmeleddin Ihsanoglu is the first to delve into this topic in any detail. Ihsanoglu's famous article *"Batı Bilimi ve Osmanlı Dunyasi: Bir Inceleme Ornegi Olarak Astronomi'nin Osmanli'ya Girisi (1660-1860)[304]"*, followed by Ben-Zaken's *"The Heavens of the sky and the heavens of the heart: the Ottoman cultural context for the introduction of post-Copernican astronomy"* are the two studies of the process of westernization/modernization of Ottoman astronomy. This thesis claims quite the contrary, i.e. that there was no Copernicization/modernization in the field of astronomy in any sense until the 19th century when modern astronomy was incorporated into the curricula of mühendishanes. Moreover, contact with Europe should not be surprising, and therefore not be overproblematized, in the context of scientific progress.

Most historians of Ottoman science have , fashioning their accounts as apologies, tried to find the innovators among the educated men of the Ottoman Empire, as if relentless development in the fundamental paradigms was a characteristic of science. That Ottomans preferred summaries and commentaries over original texts in education has also been brought to attention as a leading cause of the seeming scientific backwardness. I propose that all inquiry into Ottoman science, especially those dealing with multi-dimensional processes, such as modernization, should start out by drawing a basic intellectual and cultural matrix of *ʿilm*.

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[303] *Osm.Ast.* CXXXII-III

[304] *Belleten* LVI/217. 1992

Here, I'd like to draw attention to some of the ideas of Thomas Kuhn in lieu of a critique of this perspective. Kuhn, in his article *Function of Dogma in Scientific Research*[305] articulates, more clearly and succintly than his *Structure of Scientific Revolutions*, that science operates in paradigms rather than on them. According to Kuhn, normal scientific activity, which occupies the lifetime of most scientists, is an effort to prove and to better articulate the scientific theory the respective scientists accept. Education in the natural sciences takes place through standardized textbooks and ideas, much more so than it does in the social sciences.

As has been discussed above, "science" as a body of knowledge and as an activity is quite different than *ʿilm*. Especially the natural philosophy and the mathematical sciences had a quite different meaning then than they do now. Today natural philosophy is entirely off the table, and completely replaced by physics. The mathematical sciences, moreover, are far beyond creating pure mathematical models, but claim (and do) describe the natural world as it is known to us. In its first century, Copernican astronomy was not yet ripe enough to enjoy widespread acceptance. The maturation of the Copernican theory came with physical theories that expounded a quantitatively rational world than a qualitatively rational one. Competing theories in the debate on physics were roughly those of Descartes and Newton throughout the 18th century. The concept of gravitation, so essential to overhauling the Scientific Revolution in astronomy and natural philosophy, would not be established until later in the 18th century. First of all, then, *ʿilm-i hay ʻa*, without a comprehensive critique of natural philosophy, *ʿilm-i* tabiiye, is bound to evaluate the Copernican theory as a purely mathematical construction.

The slow process that took place in Europe naturally reflected on the Ottoman intellectual scene irregularly and haphazard ways, since those bringing in the New Science to the Ottoman Empire would not be bringing in *ʿilm*, as they would be bringing in only a side of the debate extending over a number of disciplines.

[305] A.C.Crombie, ed. *Scientific Change.* London:Heinemann, 1963. pp. 347-369

Noteworthy is the fact that of the 7 translators mentioned in the article(Tezkireci Köse İbrâhim, Ebubekir el-Dimaşkî, İbrâhim Müteferrika, Osman b. Abdülmennan, Erzurumlu İbrâhim Hakkı, Halifezâde (Çınarî) Ismail Efendi, Muneccimbaşı Hüseyin Hüsnü), only 3 of them are *medrese* graduates, and all of the translations made by these graduates were commissioned. Tezkireci's, Muteferrika's and Erzurumlu İbrâhim Hakkı's translations, although Tezkireci's translation was later presented to a patron (Kazasker Ünsi Efendi)[306], were written through personal initiative. Of these translators, all except for Erzurumlu Ibrahim Hakki, perhaps due to his neo-Platonic inclinations which he might have acquired through his sufi background, and of Osman b. Abdulmennan were against the Copernican system.[307]

Of these translations, Tezkireci's, which was later presented to Müneccimek Mehmed Efendi, Halifezâde's and Müneccimbaşı's were astronomical tables, *zîc*es, and were used to draft calendars and possibly to cast horoscopes. Again, of these works, the only two that studied the theoretical aspects of the New European astronomy were Tezkireci's and Erzurumlu İbrahim Hakkı's.

The patterns among these translations suggest two conclusions: 1) The practice of astronomy and astrology was the main driving force behind these translations, and the theories underlying such practices did not, ultimately, come under the influence of Copernican astronomy. 2) The Europeanization must not be considered as a monolithic process, since none of the translators had the agenda of explicitly modernizing astronomy in the Ottoman Empire. Most of the motives, as will be described below, were internal to the professional setting in which the translation was made. The previous section on European astronomy has sufficiently shown that European astronomy itself was not uniform, and not unambiguously modern, therefore, the translation of European works must not be unequivocally deemed as attempts at modernization. At least by the time Duret was composing his tables, many European astronomers were still faithful to their Ptolemaic origins. Later translations of the tables, on the other hand, were tables of those who were little interested in theoretical astronomy as such, but were observers, geographers and geodesists.

[306] İhsanoğlu, 1992. p.731.

[307] İhsanoğlu, 1992. p.748-9

A scientific breakthrough of the order of what Kuhn calls a paradigm shift requires the recognition of the legitimacy and the truth of the new paradigm by the relevant audience. In Europe, this paradigm shift in the sciences, the axis of which was Copernican astronomy, took place not through the universities, but both through ways independent of and occasionally and arguably opposed to the university in the 16th and 17th centuries. Major innovators, such as Tycho Brahe, Johannes Kepler and Galileo Galilei, wrote their works either through independent means, or through patronage. The communities to which they appealed, although some of them were teaching at universities, developed outside the mainstream academe. The means to disseminate the new ideas in astronomy, owed more to printing than to the established institutions of learning, and remained a matter of debate among the learned, rather than an immediately accepted hypothesis. European universities and Ottoman *medrese*s, which then shared a common Ptolemaic heritage in astronomy, did not consciously precipitate or catalyze such dissemination. Therefore, it is only reasonable to expect in the Ottoman case that *medrese*s would not be the agents of change, but change would have to come through alternate means and possibly through books and intellectual networks outside the *medrese*.

Pervasive scientific communication in an international scale requires a shared paradigm, especially if the scientific traditions are deeply rooted. Without the shared paradigm, nothing beyond pure and therefore universally applicable data can be shared, and such was the case in the various *zîc* translations from the 17th through 19th centuries. Under normal conditions, new scientific paradigms would be developed through the emergence of, and the efforts to find a solution to a technical crisis, which wasn't the case in the initial phases of the Copernican Revolution. It would be appropriate take this perspective when studying the transmission of the Western sciences, or the scarcity thereof, before the Tanzimat period. Ekmeleddin İhsanoğlu, remarks that scientific imports in astronomy from 1660 onwards were brought to the Ottoman knowledge market. Tezkireci's translation of Duret's tables is worth serious attention as a thoroughly illustrative case. İhsanoğlu claims that Tezkireci's translation made little mention of Copernican astronomy and that it dealt with practical astronomy. [308] İhsanoğlu overlooks two important aspects of this transmission. First of all, Duret's work is an astronomical table, i.e. it is not interpretive or diagnostic work of the rising Copernican tradition, but close to pure data, not *just an astronomical work that serves practical ends.*[309] Being pure data, which has no allegiance to either the geocentric or the heliocentric mathematical model, a translated *zîc* does *not* qualify as an exchange of ideas. Secondly, Durret's work was first seen as "Frenk fodulluğu"[310] by Müneccimek Şekibi Mehmed Çelebi and additional recommendation relating Durret's work to that of Ibn Yûnus and al-Zarkalî, who had prepared the *Toledan Tables* in 12th century Spain and had laid the foundation for the Alphonsine Tables that would be used until the *Prutenic Tables*[311], was necessary.[312] Müneccimek Mehmed Çelebi's initial skepticism seems to be valid, as the work seemed to be foreign to the tradition, but ultimately proved to be commensurable.

It is important to consider that while from the outside perspective that we moderns have on science, i.e. that the methods and principles themselves determine scientificity, e.g. the superiority of modern mathematical physics to Aristotelian physics), for those working within an established paradigm, say, one with which we no longer agree and have disregard for, determine the value of a work from therein. Although İhsanoğlu finally concludes that there must have been an Ottoman tradition in astronomy that served as a background to these developments, this should not be a conclusion, but rather obvious. Moreover, Ottoman astronomy seems to need no apology for its resistance, or rather, imperviousness, towards Copernican astronomy.

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[308] İhsanoğlu, 1992., pp.737-8.

[309] Recently, Avner Ben-Zaken has bolstered İhsanoğlu's claims by claiming that what Tezkireci did was a "creative adoption" of European science. Ben-Zaken takes a close look at the translation of Duret's Ephemerides Richelianae by Tezkireci Kose Ibrahim in 1660. This book, apparently written for astrological purposes, contained astronomical tables adjusted for Istanbul as well as for Paris. He highlights two aspects of this translation. 1)That the project was conceived within an illuminist framework and therefore sought to harmonize the mathematical with the physical. 2)That the book was patroned by the chief astronomer for its practical value.

[310] İhsanoğlu, 1992., p.731.

[311] Lindberg, 1992., p.268-72

[312] İhsanoğlu, 1992., pp.731, 736

According to Ben Zaken, Tezkireci's translation took place within "a creative awareness of the 'scientific revolution'"[313], and in a period when " 'Ottoman science' had closely followed European innovations and was progressing too, as a detached part of European developments." Ben-Zaken, like İhsanoğlu, sets Ottoman astronomy in an intellectual backdrop of mysticism, and in opposition to the dominant religious elements of the 17th century.[314]

In what sense were the Ottomans disconnected from Europe in the 17th century? Not in trade, for sure. A healthy flow of travellers from many parts of Europe flocked into the Ottoman lands, as had always been and always would be the case. Merchants of various nations could be found in Istanbul, Izmir and Aleppo. Indeed, most of the sources İhsanoğlu himself relies on, such as Toderini and Busbecq, in crafting his narrative of the Ottoman *medrese*s and learning were such travellers and visitors. While there is positive evidence of the proselytization activities of various churches, especially the Jesuits in the major cities, who made their way in due to the friendly relations between the Ottomans and the French, it seems we do not know precisely how they contributed to the Ottoman intellectual life. The copy of Duret Tezkireci used seems to be a gift of Richelieu to the Sultan through Harley de Césy, French ambassador to the Porte until 1640.[315] Members of the proselytizing clergy of other sects, such as Anglicans, could be found mingling with Orthodox clergy and *ʿulemâ*, highlighting the cosmopolitan structure of cities where commerce was thriving: Robert Frampton, a member of the Anglican clergy, was appointed chaplain to an English factory in Aleppo. "During his stay there after 1655 onwards, he made friends with the Orthodox patriarch, with whom he discussed religious matters, and with the chief kadi of Aleppo, with whom he drank wine."[316] A vast number of European learned men could be found in the Ottoman Empire in the 17th century. [317]

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[313] Ben-Zaken, 2004., p.1

[314] ibid. p.2

[315] ibid, p.10

[316] D. Goffman *The Ottoman Empire and Early Modern Europe.* Cambridge: CUP, 2002. p.210

[317] See A.McConnell "L.F.Marsigli's Voyage to London and Holland, 1721-1722" in *Notes and Records of the Royal Society of London*. Vol.41/1. 1986. also see above Brentjes.

While the ulama could be found in opposition to the Christian Europeans in the Ottoman Empire, one is indeed struck by how the claim that all learning, whether in the hands of *ʿulemâ* or in the hands of those who were educated through alternate means, be it as a *kâtib*, or through private lessons in various settings, was indeed closed to Europe and interactions would be the exception rather than the rule. One must always keep in mind that while books might be a good source to trace intellectual interaction, oral communication and exchange is also present, and in the 17th century, one would have a hard time distinguishing European learning from the Ottoman one, since the two traditions differed but a little in terms of substance.

Moreover, Tezkireci probably was a Christian in the earlier part of his life, and learned Latin as a part of his education within the Ottoman lands[318]. Arguably, Müteferrika himself had a similar background and he, too, translated astronomical works, and treated the competing models[319]. Such variety in educational background, in languages spoken, in sentiments and sensitivities is a matter of course. While again, it seems that the ulema wouldn't be the agents of change, there nevertheless were plenty of agents that would bring about or carry new currents in thought both from Europe and from elsewhere. Like most of the translators, Tezkireci emphasized the status of the Copernican model of the universe as a mere hypothesis. It is also noteworthy that Tezkireci treated Copernicus within the *zîc* tradition and not within the *hey'et* tradition, the European analogue of which would be the intellectual battlefield of astronomical models in Tezkireci's time.[320] This implies that Tezkireci himself must have been aware of the two distinct traditions in Arabic astronomy. Also noteworthy is the fact that the final resolution of the Copernican debate came through a debate on physics, between Newtonians and Cartesians, through which European astronomy lost its affinity with the *hey'et* tradition and became a physical science. That Copernicus's work was not was not favored by many of these translators is perhaps related to this fact, i.e. that the models of Copernicus and Kepler would never fall under a unit of specialty under the field of Arabic astronomy and would go no further than truth-equivalence vis-à-vis Ptolemy on purely mathematical grounds.

318 Ben-Zaken, 2004., p.11

319 İhsanoğlu, 1992., pp.746-7

320 ibid. P.732

Furthermore, development in observational astronomy is quite unambiguous, and such developments were followed, it seems, from within an established tradition of *zîc*. The general portrait that emerges, then, is that Ottomans did not change their established framework of astronomy and followed the developments from within that framework. That the translators of these astronomical tables favored the French also displays some discernment, as at the Paris Observatory, established by Giandomenico Cassini, some of the finest observational astronomers, geodesists and geographers of Europe held chairs.

Tezkireci found Duret's book in the Palace and presented the book to the Müneccimbaşı, which also implies that he might have been a practitioner of astronomy at the time he was preparing the translation. His work was used for drafting calendars and various other purposes by the Müneccim until it was replaced by the *zîc* of Clairaut in 1767 and later, of Cassini in 1774.[321] During the reign of Selim III, the calendars would be drafted according to the data provided by the latter.[322] In the 19th century, Lalande's *Tables Astronomiques* would be translated by Müneccimbaşı Hüseyin Hüsnî and would replace the earlier *zîc*es in the making of calendars.

The other translations and treatments of Copernicus would always treat it as a hypothesis, and as late as the 19th century, one finds that the textbooks of Mühendishâne-i Bahr-i Hümâyûn would be modelled after Kuşçu and not Copernicus, since the heliocentric system itself does not offer any mathematical advantage in regard to navigation.[323]

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[321] *Osm.Ast.* p.530

[322] İhsanoğlu, 1992., p.739

[323] İhsanoğlu, 1992., p.772

5. APPROACHES TO OTTOMAN SCIENCE

5.1. The Sources

Ottoman *ʿilm* is neither as self-contained and purely Arabic, nor as simple, as many studies have assumed. There are many factors independent of science itself that contribute to the dynamics of science, and when science is considered as an activity, many of them come to the fore. Although current scholarship shows that there was no scientific development in the early modern Ottoman Empire, one should nevertheless ask why one would expect this from the Ottoman Empire, or whether this approach is likely to bear any fruit. Ottoman *ʿilm*, considered in the larger philosophical framework, was not modern science, and whatever influences Ottoman thought might have gone under were filtered through that framework. Ottoman Empire wasn't unique or isolated in this regard, but was part and parcel of the early modern European intellectual life, one of the most outstanding characteristics of which was the competition of world-views.

Time and again one asks the question of what the history of science is. Is it the history of science as it is perceived and practiced today? Does the history of science require the knowledge of anything other than science itself? How do external factors influence science? Does the historian of science look for progress and development only? If not, what are some of the other factors that one must look into in order to understand and appreciate science and scientific ideas? These are very large questions indeed, and questions that occupy the field of the history of science in general, and the history of science in non-European cultures in particular.

The classic studies of science have always emphasized that the history of science is the history of the progress of universal science. That science today is a universal one and far more developed than all its predecessors and neighbors, valid across borders and cultures, making man powerful vis-à-vis the natural world, is a truth difficult to refute. The fruits of modern science bear witness to its validity and success. The scientific method has proven itself to be good and useful for all of us, and will continue to do so. The history of *science* traces the emergence of this universal science. From this point of view, all attention naturally turns to Europe after the Scientific Revolution of the 17th century. And from this point of view, it is with reason that many historians of European science are attracted to the modern period, and the historians of Arabic science are attracted to the pre-Copernican developments, or to the Golden Age of Arabic science that lasted until the 12th century, as it was those periods that modern science has borrowed from the most.

Yet, science wasn't always science, and scientists weren't always scientists. Not all those who studied the natural world were disdainful of astrology and symbolism, and not all followed the scientific method. Were they also practising science? Or rather, what did they think they were doing? These are also questions that need to be asked in order to find the human meaning behind science through the ages. Naturally, then, there is also another vein in the history of science that studies it in a social and cultural setting, that studies the lives and habits of those who were known to practice science *qua* inquiry into the natural world and into the order of human reason, that puts aside the development, the formulae and the figures, the discoveries and the innovations, and studies science as an activity. This latter has not been delved into in any depth in the histories of Ottoman science. That almost all historians of Ottoman science have been attracted to the history of disciplines that still exist today, and that natural philosophy, the ancestor of physics, has not been studied in the Ottoman context are both noteworthy in this regard. In fact, when Arab natural philosophy is mentioned, almost all attention turns to physics, which then naturally leads to optics, and medicine. The Ottoman case is no exception.[324]

One will often find historians of the former conviction working on the history of science in the Ottoman Empire. Sâlih Zekî was the first of the former kind. He was disdainful of Ottoman learning that fell along the lines one finds in the writings of Taşköprüzâde, who was one of the articulators of the general shape of learning in the 16th century Ottoman empire. Sâlih Zekî certainly believed in the universality of science and favored the moderns over the ancients. In his *Âsâr-ı Bâkiye*, he studied the

[324] See E.İhsanoğlu. "Osmanlı Bilim Tarihi Konusundaki Araştırmalar Hakkında Bazı Notlar" in *Osmanlı Bilimi Araştırmaları*. İstanbul: İstanbul Üniversitesi Yayınevi, 1995. for an enumeration of the fields that have received attention by researchers in the field.

history of trigonometry in the mediaeval Islamic world with such sentiments, and tried to see how the Muslims had contributed to present day trigonometry. To him, "scholasticism" that characterized classical Ottoman thought, and to some extent, early 20th century Ottoman thought as well, was "backwards", and was in opposition to true science:

> Distinguished individuals belonging to this group [of *medrese* graduates] also have a disregarding eye for true learning. If you introduce a man who is involved in "true learning", which we call "Western learning, to one such *savant*, you immediately belittle him in the eyes of the *savant*.
>
> To place him in the highest regard of the *savant*, you should rather say:
>
> - My dear Sir! He is learned in the sciences, useful and noble! Many are his works in prose and verse! Not the least of his achievements is a commentary on the Treatise of Gelenbevi! His mastery of optics is extraordinary; and the breadth of his erudition is remarkable! The way he works with the astrolabe is no less than uncanny![325]

In this article, Sâlih Zekî suggested that the Ottoman Turkish equivalent of "scholasticism" would be "*medresiyat*". He argued that a healthy stock of traditional learning and the gallant use of reason, which operated on the belief that the traditional learning gave one all the necessary knowledge, based on this learning characterized the intellectual attitudes of most Ottomans. He complained about the unappreciative and hostile attitudes of the *medrese*-educated towards modern, or "true", science.

[325] "Bir de bu sınıfa [*medrese*li] dahil olan zevat-ı kiramda maarif-i hakikiyeye karşı nazar-ı istihfaf da vardır. Medeniyet-i hazıranın tavsiye ettiği, bizim "maarif-I garbiye" dediğimiz, "maarif-i hakikiye" ile mütehalli bir zatı kendilerine takdim ettiniz mi hemen o anda efendinin nazarında bu zatı küçültmüş olursunuz.
Zira efendinin nazarına sokmak için:

- Efendim! Ulum-u âliye ve 'aliyeden mezun! Manzum ve mensur bir çok asarı var! Burhan-ı Gelenbevi'ye bir de haşiye yazmıştır! Bundan başka *ʿilm-i* menazirde ve *âdâb*da mahir, hele *ʿilm-i* usturlabda efail-i acibeye kadirdir!

demeli!" "İskolastik" in *Darüşşafaka* year 1, no.10. 1 Mart 1326(1910) İstanbul, published in *Skolastik Eğitim ve Türkiye'de Skolastik Tarz: Salih Zeki, Yusuf Akçura, Muallim A. Cevdet.* Ed. & Tr. Hasan Ünder, pp.90-96, p.94 Ankara: Epos, 2002)

Sâlih Zekî's *Âsâr-ı Bâkiye* is a substansive evaluation of the development of history of arithmetic, algebra and trigonometry and offers a satisfying account of the various theorems discovered from the 9th century until the 15th century, and also traces the influence of earlier developments in trigonometry on Regiomontanus. The book is the fruit of Sâlih Zekî's excursion into the manuscripts then available at the Hagia Sophia library and takes a historical-developmental approach to the history of science. He pays attention to the linear development, and considers science to be universal, i.e. not divided by scientific ecumenies and by periods. He decontextualizes the material and treats it as pure trigonmetry. The book critically assesses some of the dominant opinions on Arabic science, advanced in the 18th and 19th centuries in Europe, and also treats the contributions of Arabic mathematicians after the 12th century to the development of the field. There is some material on Kuşçu and Kadızâde-i Rûmî, yet little that hasn't been incorporated into later works, and includes a bio-bibliographic accounts of Takiyüddîn and Gelenbevî, whose mathematical writings enjoyed popularity as textbooks in the Ottoman Empire. This book has recently been published in modern Turkish by Melek Dosay Gökdoğan, Remzi Demir and Yavuz Unat[326], whose works will be discussed below.

One can find other bio-bibliographical works from the earlier part of this century, such as those of Suter[327]. This work, which was consulted in the preparation of this thesis, again, offers little to the researcher after the manuscript catalogues have been published by Ekmeleddin İhsanoğlu on the various sciences in the Ottoman Empire. Suter's work, like the works of Wiedemann and many other orientalists, borrows largely from Katip Çelebi's *Keşfü'z-zünûn* in tracing the history of Arabic science into the Ottoman centuries. These works incorporate the Ottoman history of science into the larger framework of Arabic science. Sezgin's volumes remain valuable source material, since included in them are critical editions and manuscripts of some of the works influential in the Ottoman Empire.[328]

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[326] S. Zeki. *Âsâr-ı Bâkiye*. 3 vols. Ankara: Babil,2003.

[327] H.Suter. *Beiträge zur Geschichte der Mathematik und Astronomie im Islam*. ed. Fuad Sezgin. Frankfurt : Institut für Geschichte der Arabisch-Islamischen Wissenschaften, 1986[1922].

[328] *Islamic Mathematics and Astronomy*. ed. F. Sezgin. 107 vols. Frankfurt, 1997-2001.

The first comprehensive work on the history of science in the Ottoman Empire is by Adnan Adıvar, who himself was at a loss about where to begin such a history or what science among the Ottoman Turks was, and takes the first established *medrese* as a starting point. Adıvar remained the standard work from which most subsequent studies were inspired, since it provides the reader the names and works of some of the outstanding figures. It is particularly strong on the history of medicine and geography, yet Aykut Kazancıgil's *Osmanlı'da Bilim ve Teknoloji*[329] has surpassed it in both. Kazancıgil's book incorporates a very good bibliography into the narrative of Adıvar, since Kazancıgil's book quotes very generously from Adıvar and follows a similar pattern. Substansive research into Ottoman medicine in the decades after Adıvar's book makes Kazancıgil's account of medicine much richer and much better organized than Adıvar. There are a number of additions from other aspects of Ottoman science and adequately reflects the general scheme of contemporary research in Turkey.

Osmanlı Türklerinde İlim is a pessimistic book, since he too takes the Arabic science until the 12th century as the point from which decline began. In his introduction to the Turkish edition, he gives his verdict on Ottoman Science:

> Those who read this work will find that the positive sciences in Ottoman Turkey until the 19th century are only an incomplete and sometimes flawed continuation of "science in the Arabic and Persian language" and that its general shape, either in conter or in form, is no different than the form science has taken with the passage of the "Greek miracle" to the East. Yet one will also find that the rare periods when these sciences have walked the path of progress through taking ideas and methods from the West are also emphasized. [330]

Like his predecessor, Sâlih Zekî, he doesn't look kindly upon the Ottomans, but nevertheless does indulge himself in an anectodal, and often out of place, historical narrative trying to show that one could find Turks who were empirically sensitive. In

[329] İstanbul: Ufuk, 2000.

[330] In the preface Adıvar says: "Bu eseri okuyanlar, Osmanlı Türkiyesinde müspet ilimlerin XIX. yüzyıla kadar ancak "Arap ve Fars dillerindeki ilim"in eksik ve bazen de yanlış bir devamından ibaret olup, ne muhteva, ne de metot bakımından "Yunan mucizesi"nin Doğuya geçmesiyle aldığı şekilden ayrı bir şekil olmadığını, ama bu ilimlerin, Batıdan fikir ve metot alarak, yeniliğe doğru yürüdüğü nadir safhalar olmuşsa, onların önemle belirtildiğini göreceklerdir."

Osmanlı Türklerinde İlim, one finds a combination of positivism and nationalism. The Istanbul edition differs from the Paris edition mainly in the incorporation of short passages on the scientific developments in the West. An edition with various addenda has been published by Sevim Tekeli and Aykut Kazancıgil and was the edition used in the preparation of this thesis.

According to Adnan Adıvar, there are very few high points, and those are associated with Mehmed II, Maritime Geographers, the Müteferrika's press and the developments in the military technology from the end of the 18th century onwards. 19th century is treated as the definite period of change. The larger periodization falls along the lines of the decline of the *medrese*, and anything posterior to the end of the 16th century is taken to be a part of the decline of the *native* elements to gradual disintegration. The colossal work of Cahid Baltacı[331], and Uzunçarşılı's *İlmiye Teşkilatı* [332] also attest to this.

The next generation of scholars, the most prominent of which are Aydın Sayılı, A.Süheyl Ünver and Fatin Gökmen, who are often seen working together, have accepted this account for the most part, but unlike Sâlih Zekî and Adıvar, have studied particular aspects of science in the Ottoman Empire. Published in 1960, Sayılı's *Observatory in Islam* still remains one of the standard works for the history of Arabic astronomy, and like many others written Sayılı's, is one of most scholarly works, if not the most scholarly, on the Ottoman history of science that has been done in Turkey. While Sayılı's interest remained science in the Arab scientific ecumene at large, he has also probed into some of the critical moments in the history of Ottoman science. His approach is civilizational, as seen from the fact that most of his works treat European and Arabic science in comparative perspective. Since his main line of inquiry was the observatory, several of his articles have revolved around the Istanbul Observatory. One such study is his *Üçüncü Murad'ın İstanbul Rasathanesindeki Mücessem Yer Küresi ve Avrupa ile Kültürel Temaslar*[333], therein he remarks how fast certain scientific developments make their way into the Ottoman Empire, and questions how such

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[331] C.Baltacı. *XV-XVI. Asırlarda Osmanlı Medreseleri* Istanbul: Irfan, 1976. p.617

[332] See pp.67-75

[333] *Belleten* XXV 1961

technical competence was achieved, since geography was not taught in the Ottoman *medreses* until the 19^{th} century.[334] He proposes that private tutoring must have been available in geography in the Ottoman lands,[335] which, proposes an interesting field of inquiry - but one that nevertheless requires extraordinary diligence. He has also written on Alâaddin Mansûr's poems on the Istanbul observatory and on the comet of 1577, which have been partially incorporated into his Observatory in Islam.

In a comparative study, *Islam and the Rise of the Seventeenth Century Science*[336], Sayılı asks an important question that should have a bearing on all studies of science in the Ottoman Empire: Is it the natural course of science to develop and progress? A corollary to this question was whether Greek science was open to much further development at the end of late antiquity, i.e. whether there were internal limitations to advancement in the sciences that follow the Greek tradition. Since most other authors whose work on Ottoman science he was familiar with, such as Adıvar and Ünver, had always put the blame on religion for the lack of scientfic development in the Ottoman Empire, this seems to be a refreshing question, much better than the necessarily polemical debates that Adıvar and Ünver were engaged in. The debate over the relationship between religion and science continues to this day in the histories of Ottoman science, and İhsanoğlu himself has taken the side of religion in this debate.

Süheyl Ünver was a prolific scholar, and has written extensively on education and science in the Ottoman Empire. To date, his *İstanbul Rasathanesi* remains the only comprehensive monograph of the İstanbul observatory. It is a better source for the actual historical process of the building, the operation and the demolition of the observatory than Sayılı's chapter in the Observatory in Islam. Fatih Külliyesi, too, is quite scholarly regarding the history, operation and architecture of Fatih Külliyesi, and offers insights into the curriculum of the *medrese*, although İhsanoğlu has heavily criticized this work, since Ünver claimed, quite preposterously, that İstanbul University was the descendant of Fatih Külliyesi, thereby honoring the quite recent

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[334] ibid. p.427

[335] ibid. p.432

[336] *Belleten* XXII/87 1958

establishment with a 500 year history.[337]While Süheyl Ünver's scholarship is, for the most part, commendable, as he takes care to expose a great amount of primary sources, his nationalism and scientism often shines through in a manner unbecoming to his otherwise substantial inquiry. Ünver has a point to prove: that *Turks*, left to their own devices and stripped from foreign elements, are a scientifically minded nation indeed. To him, Murad III's interest in astrology, which seems to be the reason for the building of the Observatory in Istanbul, had developed under the influence of foreign women in the *harem*. And ultimately, intrigues and interests , were the main factor in the falling of this star in the

> Although Taqi al-Din's observatory fell prey to the competition and indignation among those whose sole principlein life was to keep their domineering ranks in government service, they were powerless against Taqi al-Din's vigorous scientific personality. This should be taken as an expression of how fortune itself cannot stick her fangs into those whose science rests upon solid foundations.[338]

The works mentioned so far have been conducted in more or less amateur spirit. The professionalization of the history of science in Turkey began in 1955. Aydın Sayılı, after having received his doctoral degree at Harvard under George Sarton, established the Chair of the History of Science at Ankara University. Despite its long history, most of its research antedates 1982, when the chair was turned into a department. The department has published a total of 59 books and 294 articles, most of which, again, have been published after the 80's, a complete bibliography of which has been

[337] See "The Initial Stage of the Historiography of Ottoman *Medrese*s (1916-1965), The Era of Discovery and Construction" in E.İhsanoğlu. Science, Technology and Learning in the Ottoman Empire. Aldershot:Variorum, 2004. / "Fatih Külliyesi *Medrese*si Ne Değildi!" in E.İhsanoğlu *Osmanlılar ve Bilim:Kaynaklar Işığında Bir Keşif.* Istanbul: Nesil, 2003

[338] "Fakat devlet idaresinde ihtiraslı mevkilerde kalmağı prensib tutanlar arasında rekabete ve çekememezliğe kurban giden Takiyüddinin her ne kadar Rasadhanesi ebediyyen tarihe karıştırılmış ise de kuvvetli ilmi şahsiyetine birşey yapamamışlardır. Bu da ilmi ciddi esaslara bağlı olanlara feleğin bile diş geçiremediklerinin bir ifadesi sayılmalıdır." Ünver, 1969. p.71

prepared by Yavuz Unat.[339] A similarly comprehensive bibliography for the History of Science Program at Istanbul University in the same volume.[340]

Sevim Tekeli's work mostly dating from the late 1950's and 60's, Sayılı's first student, has concentrated her studies on the astronomical instruments and trigonometry of Takiyüddîn. A good comparative study of the instruments of Tycho Brahe and Takiyüddîn may be found in her "Nasırüddîn, Takiyüddin ve Tycho Brahe'nin Rasat Aletlerinin Mukayesesi"[341], the similarity between the instruments used at Uraniborg and Istanbul is remarkable, and the two observatories lie at the technical zenith of observational astronomy before the introduction of the telescope. *"16'ıncı Yüzyılda Osmanlılarda Saat ve Takiyüddin'in "Mekanik Saat Konstrüksüyonuna Dair En Parlık Yıldızlar" Adlı Eseri"*, put side by side with Sayılı's articles on Taqi al-Din provides the reader with some perspective on how scientific knowledge was produced, acquired and disseminated in the 16th century Ottoman Empire. It speaks of the various types of clocks Takiyüddîn worked on and mentions that Takiyüddîn got in contact with various European scientists at the court of Semiz Ali Paşa and invites further research into the means and routes of interaction and communication. Esin Kahya, whose name should also be mentioned, has worked on the history of medicine in the Ottoman Empire.

In 1984, Istanbul University, with the initiative of Ekmeleddin İhsanoğlu, has also established a department in the history of science. Working in cooperation with the Department of the History of Science in Ankara University and IRCICA, which was headed by İhsanoğlu until recently, the department has published extensively on the various aspects of Ottoman science. After the 1980's, a good number of scholarly works have been published by a younger generation of scholars, including Feza Günergun, Salim Aydüz, Cevat İzgi and İhsan Fazlıoğlu at the Istanbul University, and Remzi Demir, Yavuz Unat and Melek Dosay Gökdoğan in Ankara. These works are not concentrated in any one particular field, but astronomy and mathematics seem to be

[339] Y.Unat. "AÜ.D.T.C.F. Bilim Tarihi Anabilim Dalı" in *TALID* vol.2/4 2004 pp.493-521.

[340] For a list of theses and publications, see F. Günergun "İ.Ü. Bilim Tarihi'nin Kurumsallaşması: Araştırmalar ve Eğitim Programları" in *TALID* vol.2/4 pp.545-580

[341] *AÜDTCF Dergisi* vol.XVI/3-4. 1958

two centers of attention. With the formation of a scholarly community, less known works that reflect the standard fare of an Ottoman scholar have begun to be studied.[342] However, the general decline paradigm has not yet been surpassed, and a new and deeper level of understanding has not yet been reached.

Cevat İzgi's seminal work, *Osmanlı Medreselerinde İlim*, makes use of many primary sources and is, by and large, an original work. The work is a compilation vast number of sources on the *medrese*s and the *ʿulemâ*. Therein, Cevat İzgi sets out to show that the various branches of natural philosophy and the mathematical sciences have been studied, and also how they were being studied in a *medrese* setting. Prior accounts of the *medrese* curricula had often claimed, usually based on a certain reading of Katip Çelebi's criticisms of the *medrese*s of his time, that natural philosophy and mathematics were not being studied at the *medrese*s after a certain period. The evidence against this claim, presented by İzgi, is conclusive and satisfying in comparison to prior works. Another problem lies in the fact that İzgi forces the modern scientific disciplines on the Ottoman setting and therefore, one does not get a truly faithful portrayal. At any rate, İzgi's work remains an important source of primary material in transliterated and translated form and has been used extensively in the preparation of this thesis.

Of world-wide scholarly interest are the series of manuscript catalogues supplemented with biographical material published under the editorship of İhsanoğlu. *Osmanlı Astronomi Literatürü Tarihi*, *Osmanlı Coğrafya Literatürü Tarihi* and *Osmanlı Matematik Literatürü Tarihi*[343] are of this kind. These works offer the additional advantage of including a summary of the latest scholarship on each author, and thereby offers a good bibliography of secondary as well as primary sources. They mark a new turning point in the history of Ottoman science, and also serve as an Ottoman version of *The Dictionary of Scientific Biography*. With the emergence of these works, statistical studies have also begun to emerge. İhsanoğlu in a recent article also

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[342] Y.Unat *Mir'atü'l-Alem: Ali Kuşçu'nun Fethiyye adlı eserinin çevirisi*. Ankara: Kültür Bakanlığı, 2001.

[343] Istanbul: IRCICA, 1997,1999, 2000 respectively.

attempts a statistical study based on these catalogues[344]. Following the lead of Sayılı and Tekili, Remzi Demir has published a mathematical work of Takiyüddîn.[345] Published by Yavuz Unat are two critical editions: al-Fargânî's *Elements of Astronomy* (Harvard, 1998) and Seyyid Ali Paşa's translation of Ali Kuşçu's *Fethiye* (Ankara, 2001)

Sayılı himself published most of his works in the periodical Belleten and until late 1990's, and most of the material on the history of science may be found therein. Today, most articles on the history of science are published in *Erdem*, *Araştırma* and *Osmanlı Bilimi Araştırmaları.* Osmanlı Bilimi Araştırmaları has proven useful in the preparation of this thesis.

5.2 New Approaches ?

Ekmeleddin İhsanoğlu's approach to science has been extensively treated in the Astronomy chapter. He does take some of the elements that have been accepted and formulates a novel and tactful approach, but equates the introduction of Western elements with modernization. Moreover, he assumes that the development of Copernican astronomy owed mostly to the religious debates in Europe, and omits the technical elements that were involved, and entirely misses the connection between the technical debates on Copernican astronomy and natural philosophy and consequently, in the opinion of the present author, misanalyzes the process and the nature of the transmission.

Two attempts, one by Remzi Demir, and one by İhsan Fazlıoğlu have been made in order to set a new course for the study of Ottoman science. Fazlıoğlu sets out by asking "First, science in the Islamic-Ottoman Civilization is studied only insofar as it fits the definition of science described above and in proportion to its influence on the West." [346] He also describes the subtext of the Ottoman scientific tradition as

[344] E. İhsanoğlu "Ottoman Educational Institutions" in *Ottoman Civilization* vol.1 ed. H.İnalcık & G.Renda. Istanbul: Ministry of Culture, pp.340-1

[345] *Takiyüddin'de Matematik ve Astronomi*. Ankara, 2001.

[346] "Her şeyden önce İslam-Osmanlı Medeniyetinde bilim, günümüzde büyük oranda yukarıda verilen bilim tanımını *andıran* ve Batı'ya *etkisi oranı*nda dikkate alınan bir

manifested in the texts. Histories and debates are incorporated into the written works, and the presence and multiplication of such discussions is a universal phenomenon in all *şerh*s and *haşiye*s. Moreover he takes Katip Çelebi to be standing outside the mainstream of Ottoman science, and remarks, like Adıvar, that beginning with Katip Çelebi, this historical consciousness was further stimulated, and distinguishing between what is Islam's own and what is Ottoman became an increasing concern. Fazlıoğlu also goes on to level a further discrepancy, one that is often not recognized, between the applied and theoretical sciences and the apparent disdain for the presence of practice and technology in learning among the *ʿulemâ*.[347]And he notes that even those who are known to bring in the modern sciences into the Ottoman Empire, such as Başhoca İshak Efendi, gave the priority to Islamic and Ottoman learning, and complained about how the Europeans tried to credit themselves for everything pertaining to science. Moreover, from the Tanzimat onwards, many Ottoman intellectuals discredited all traditional learning that did not contribute to Western science. The torch theory of science, Fazlıoğlu argues, has led scholars of Ottoman and European science to use many different concepts, such as race, language and civilization without any discernment.[348] And he believes, like Demir, that studies on Ottoman science should first clean the table from the old debates and should adopt a new approach that takes into account both the historical and the civilizational perspective, proceeds from close textual analysis, clears the boundaries of debates on nationalism, distinguished the modern sciences such as physics from ancient fields of learning such as natural philosophy and reconstructs Ottoman science with the organizational guidelines to be found in works like *Mevzuatü'l-Ulum*.

One criticism that could be voiced against Fazlıoğlu's agenda is that it over-particularizes the Ottoman case. While the historically conscious method of transmission and progress of learning prevalent in the Ottoman Empire, one should nevertheless keep in mind that until late 18th century, Ottomans still shared the same

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alandır." p.13 in İki Ucu Müphem Bir Köprü: 'Bilim' ile 'Tarih' ya da 'Bilim Tarihi' in *TALID* vol.2/4. 2004

347 ibid. pp.15-6

348 ibid. p.18

liberal arts approach to learning that was prevalent in Europe. Moreover, what Gavroglu calls the *peripheries* of modern science, such as Greece, also had the same historically conscious approach, and one could say that Aristotle's legacy was, for the most part, uninterrupted, but rather adapted to evaluate the New Science. And finally, one must keep in mind that New Science was spread by a process reminiscent of the punctuated equilibrium. New Science outmoded and outnumbered Aristotelian Science. It set out by the premise that Aristotelian science was useless and unprogressive, and did not proceed by technical demonstrations against and refutations of Aristotelian science. Therefore, it is only natural that Aristotelian science would endure in various parts of the world, where interactions and communications might be more common than we assume, but also practically invisible compared to the protruding influences of Modern Science on such "peripheries". One such case where transmission from the paradigm-wise akin Greek learning to Ottoman Empire by Es'ad Yanyevî. From the outside perspective, Yanyevî's new translation of Aristotle's Physics from Greek and Latin sources, when diagnosed as a translation does not contribute in any appreciable way to the already existing Ottoman tradition, and if we had no historical records surrounding the translation, it would be difficult to recognize that it was a case of transmission.

Remzi Demir's approach[349] is quite different, and more or less sociological. The work evaluates Ottoman science in a way similar to Huff's evaluation of Arabic science, at least in terms of parameters of evaluation, and reiterates the religious element in the Ottoman society. He underlines the similarities in method and ancestry between the Ottoman Empire and Europe, and like Toby Huff, underlines the importance of Latinization and then vernacularization of written works in Europe to the development of science.[350] He notes that most introductory scientific works were written in Turkish while the more sophisticated treatises continued to be written in Arabic.[351] Demir also highlights the antithetical relationship between religion and science, and takes secularism as a necessity for scientific development, and interlinks the Ottoman and the medieval European case in their shared tradition of

[349] *Osmanlılar'da Bilimsel Düşüncenin Yapısı.* Ankara: Epos, 2001.

[350] ibid. p.14

[351] ibid. p.33

scholasticism.[352] He also treats nizâm-ı âlem as a factor, and thinks that the prestige of traditional learning was proportionate to the prestige of the ʿ*ulemâ* and is partially responsible for the extended lifespan of traditional learning.[353] Moreover, Sufism has led the Muslim community to sloth and inertia, and is also to blame for the Ottoman backwardness in science.[354] He also claims that the military did for the Ottoman Empire what the bourgeoisie did for Europe, i.e. replaced the ancien régime, politically and intellectually.[355]

Demir seems to expound the story that has been expounded by many before. He considers science to mean modern science, and evaluates the Ottoman case from this angle. Unlike Fazlıoğlu, Demir maintains that science is not the norm but the exception in the Ottoman case, and the history of Ottoman science is nevertheless bound to be a history of exceptions. Demir's work is an excellent exposition of the underpinnings of the established way of studying Ottoman science. He, like Adıvar, divides Ottoman science into two periods, based on modernization: 14th-19th century and 19th-20th century.

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[352] ibid. p.53

[353] ibid. p.59

[354] ibid. p.73

[355] ibid. p.64

6. CONCLUSION

While this thesis was initally intended to trace scientific development in the Ottoman empire in early modernity, it has rather traced non-development. From a pure history of science perspective, there is nothing intrinsically interesting about tradition and traditionalism in science, especially in those traditions qualified as *backwards* in relation to contemporaneous developments: Just as early medieval Europe received little attention from historians of science, post-twelfth century Arabic science, of which Ottoman science is considered a part, has also been relatively unattended. Sâlih Zekî, and especially Adnan Adıvar showed disdain for scientific activity in the Ottoman empire precisely because they were following this approach.

In order to properly problematize and explain Ottoman science, which is a case of non-development, one should also take into account the sociology of knowledge. The first logical step in this direction is to distinguish between science and *'ilm* as two different modes of approaching the study of nature. While the scientist seeks to understand a particular part or aspect of nature, the *'âlim* seeks to understand the whole. While the scientist is interested in the immediate causes of natural phenomena and is actively engaged in his subject-matter through experiment, the *'âlim* is interested in where phenomena fit in the larger scheme of the natural world and remains a passive observer. The disciplinary divisions that define the area of competence of the scientist did not exist then, and most students of nature were also competent in other fields of learning, such as philosophy and history. *'Ilm* used to connote many branches of learning, and only a certain number of these branches involved the study of nature. The study of nature in the context of *'ilm* is roughly equivalent to what one may call natural philosophy, in contradistinction to natural science.

Furthermore, considering that whatever Ottoman *'ilm* inherited from earlier Arab learning was also inherited by late medieval Europe, there also seems to be a historical connection between *'ilm*, and the natural philosophy that was *slowly* abandoned in Europe after the emergence of modern science. Especially in the field of astronomy, one sees that the European background of, and resistance to, the development of Copernican astronomy, a process which culminated in the 17th century, was not at all different from the intellectual climate of the Ottoman empire. Medieval scientific traditions, characterized by geocentrism in astronomy, held sway in both scientific ecumenes until much later than 1543, when Copernicus's *De Revolutionibus* was printed.

Although few Ottoman Muslims, most of whom have converted to Islam later in their lives, are known to be educated in Europe; nevertheless, many of the non-Muslims residing in the Ottoman went especially to Italy to get higher education. Greek learning has been treated in this thesis, and it displays ample evidence that the non-development which characterizes Ottoman science was not unique to Muslim learning in the Ottoman empire, but reacting, whenever any attention was paid, to modern science was also quite prevalent among the Greeks until the late 18th century. At any rate, modern science was not thought to be truer, or to have a greater heuristic potential, than its medieval counterpart, but rather, was taken as a competitor among many competitors against Aristotelian learning. Many of those who have reacted to modern science across borders during its inception shared a common body of learning, and a shared set of intellectual sentiments and sensibilities: Both physically, through intellectual networks, and ideally, through ancient Greek and Arabic learning.

The Ottoman reaction to Copernican astronomy, which has been treated in this thesis, was more than mere dogmatism. The Ottoman reaction voiced concerns that were shared by many others, in Europe as well as elsewhere, and had technical and philosophical features that have often been omitted, or under-valued, in the scholarly treatments of Ottoman astronomy. The author has tried to show that a richer and more faithful account of Ottoman astronomy may be written only if the technical and philosophical properties and strengths of Aristotelian learning are duely evaluated.

It is crucial that the history of Ottoman science is written comprehensively and faithfully. Ottoman science is not science among Ottoman Turks or Ottoman Arabs: That would only place artificial barriers between the Muslims and the other groups who cohabited the Ottoman lands and interacted intellectually with each other.

Neither classical Arab learning nor early modern European learning was bound by borders, and one should only expect that intellectually compatible ideas freely flowed back and forth, just like commerce, in the Mediterranean geography. Ottoman science was not restricted to resources offered by medieval Arabic science, just as European science was not restricted by medieval European learning. Tracks of education in both scientific ecumenes were strikingly similar, as were the ideas. Earlier Arabic learning is only as much a context of Ottoman science as early modern European science.

SELECTED BIBLIOGRAPHY

The Encyclopaedia of Islam: new edition. ed. H. A. R. Gibb ... [et al.] Leiden: Brill; London: Luzac, 1986-

İslâm ansiklopedisi. İstanbul: Türkiye Diyanet Vakfı İslam Ansiklopedisi Genel Müdürlüğü, 1988-

İslâm ansiklopedisi: İslâm alemi tarih, coğrafya, etnografya ve biyografya lugatı. Ankara: Milli Eğitim Bakanlığı, 1997.

Islamic Mathematics and Astronomy. ed. Fuad Sezgin. Frankfurt, 1997-2001.

A History of the University in Europe, ed. H. de Ridder-Symoens. Cambridge, UK: CUP, 1996.

Great Books of the Western World vol.16 Ptolemy, Copernicus, Kepler. ed. Mortimer Adler. Chicago: Encyclopaedia Britannica, 1952.

Sicill-i Osmanî [Mehmed Süreyya] ed. Nuri Akbayar ; tr. Seyit Ali Kahraman, ind. Yücel Demirel. İstanbul: Tarih Vakfı, 1996.

28 Mehmed Çelebi. *Kafirlerin Cenneti.* ed. G.Veinstein, tr. M.A. Erginöz. İstanbul: Ark, 2002

Adıvar, A. Adnan. *Osmanlı Türklerinde İlim 6th ed.* ed. A.Kazancıgil and S.Tekeli. Istanbul: Remzi, 2000[1943]

Aiton, E.J. "Peurbach's Theoricae Novae Planetarum: A Translation with Comentary" in *Osiris, 2nd series*. vol.3. 1987

Aristotle. *Metaphysics*

Ashworth, William. "Catholicism and Early Modern Science" in *Science in Europe, 1500-1800*. ed. Malcolm Oster., pp.117-134. Milton Keynes, UK: Palgrave/Open University, 2002.

Aydın Sayılı. "Tycho Brahe Sistemi Hakkında XVII. Asır Başlarına Ait Farsça Bir Yazma. *Anatolia*, vol.3. 1958.

Aydüz, Salim. "Osmanlı Devleti'nde Müneccimbaşılık" in *Osmanlı Bilimi Araştırmaları.* Istanbul: Istanbul University Press, 1995 ,

Babinger, Franz. *Mehmed the Conqueror and His Time*. tr. Ralph Manheim ; ed. William C. Hickman. Princeton : Princeton University, 1978.

Bakar, Osman. "Science" in *History of Islamic Philosophy*. Eds. Nasr, S.H and O. Leaman. London: Routledge, 2001.

Baltacı, Cahid. *XV-XVI. Asırlarda Osmanlı Medreseleri* İstanbul: İrfan, 1976.

Bayrakdar, Mehmet. *İslam'da bilim ve teknoloji tarihi*. Ankara:Diyanet Vakfı, 2000.

Ben-Zaken, Avner. "Osmanlı İmparatorluğu'nda Bilimsel Faaliyetler" tr. H.Kapu & M.Yavaşi in *Türkler,* vol. 11. ed. Hasan Celal Güzel, Kemal Çiçek, Salim Koca. Ankara : Yeni Türkiye Yayınları , 2002.

Ben-Zaken, Avner. "The heavens of the sky and the heavens of the heart" in *BJHS,* 37. 2004

Berkeley, George. *The Analyst: A Discourse Addressed to an Infidel Mathematician.* http://www.maths.tcd.ie/pub/HistMath/People/Berkeley/Analyst/Analyst.pdf.) ed. D.R. Wilkins.Trinity College. Dublin, Ireland. 2002.

Bosworth, C.E. "A Pioneer Arabic Encyclopaedia of the Sciences: Al Khwarizmi's Keys of the Sciences" in *Isis*. vol.54/1. 1963

Brentjes, Sonja. "On the Relation Between the Ottoman Empire and the West European Republic of Letters (17th-18th centuries)" in *International Congress on Learning and Education in the Ottoman World* /Istanbul 12-15 April 1999/ Proceedings., Istanbul: IRCICA, 2001.

Brotons, V.N. "The Reception of Copernicus in Sixteenth-Century Spain: The Case of Diego de Zuniga" in *Isis* vol.86/1. 1995.

Burke, Peter. *A social history of knowledge : from Gutenberg to Diderot*. Malden, MA : Blackwell, 2000

Burnett, C. "The Coherence of the Arabic-Latin Translation Program in Toledo in the Twelfth Century" in *Science in Context* vol.4/1-2. 2001.

Butterfield, Herbert. *The Origins of Modern Science: 1300-1800*. New York: Macmillan, 1957.

Carmody, F.J. "Notes on the Astronomical Works of Thabit ibn Qurra" in *Isis* Vol.46/3 1955

Carmody, F.J. "Regiomontanus' Notes on al-Bitruji's Astronomy" in *Isis* vol.42/2. 1951.

Cavazza, M. "Bologna and the Royal Society in the Seventeenth Century". in *Notes and Records of the Royal Society of London.* Vol.35/2. 1980.

Christianson, J.R. "Tycho Brahe's German Treatise on the Comet of 1577: A Study in Science and Politics" in *Isis* vol.70/1. 1979

Collingwood, R.G. *The Idea of Nature.* New York: OUP, 1960 [1945]

Crombie, A.C. *Scientific Change.* London:Heinemann, 1963.

Dales, Richard C. *The Scientific Achievement of the Middle Ages.* Philadelphia: University of Pennsylvania Press, [1973]

Demir, Remzi and Unat, Yavuz. "Ali Kuşçu ve El-Muhammediyye, El-Fethiyye ve Risale fi Hall Eşkal El Mu'addil li'l-Mesir Adlı Eserlerinin Türk Bilim Tarihindeki Yeri" in *Düşünen Siyaset* 16.

Demir, Remzi. *Osmanlılar'da Bilimsel Düşüncenin Yapısı.* Ankara: Epos, 2001.

Demir, Remzi. *Takiyüddin'de Matematik ve Astronomi.* Ankara, 2001.

Demos, Raphael "The Neo-Hellenic Enlightenment" *Journal of the History of Ideas.* Vol.19/4. 1958.

Descartes, René. *Philosophical Essays and Correspondence*. Ed. R. Ariew. Indianapolis: Hackett, 2000.

Eisenstein, Elizabeth L. *The Printing Revolution in Early Modern Europe.* New York : Cambridge University Press, 1993.

Fazlıoğlu, İhsan. "İki Ucu Müphem Bir Köprü: 'Bilim' ile 'Tarih' ya da 'Bilim Tarihi'" in *TALID* vol.2/4. 2004

Fück, Johann W. *Die arabischen studien in Europe.* Leipzig : Otto Harrassowitz, 1955.

Dialetis, D., K. Gavroglu and M. Patiniotis. "The sciences in the Greek-speaking regions during the seventeenth and eighteenth centuries", in Kostas GAVROGLU (ed.), *The Sciences in the European Periphery during the Enlightenment*. *Archimedes*, vol. 2 [series editor Jed Buchwald], Dordrecht, Kluwer, 1999.

Geanakoplos, Deno J. *Greek Scholars in Venice: Studies in the Dissemination of Greek Learning from Byzantium to Western Europe.* Cambridge: CUP, 1962.

Gingerich, Owen. *The Eye of the Heaven: Ptolemy, Copernicus, Kepler.* New York, NY: AIP, 1993

Goffman, Daniel. *The Ottoman Empire and Early Modern Europe.* Cambridge: CUP, 2002

Gökmen, Fatin. *Rubu tahtası: nazariyatı ve tersimi.* Ankara : Milli Eğitim Bakanlığı, 1948.

Gökyay, Orhan Şaik. *Kâtip Çelebi: Yaşamı, Kişiliği ve Yapıtlarından Seçmeler.* İstanbul: T.C. İş Bankası Kültür Yayınları, 1982

Grafton, Anthony. "Kepler as Reader" in *Journal of the History of Ideas* vol 53/4. 1992

Grant, Edward. “Late Medieval Thought, Copernicus and the Scientific Revolution” in *Journal of the History of Ideas*. Vol.23/2. 1962.

Günergun, Feza. “İ.Ü. Bilim Tarihi’nin Kurumsallaşması: Araştırmalar ve Eğitim Programları” in *TALID* vol.2/4 pp.545-580

Gutas, Dimitri. *Avicenna and the Aristotelian tradition : introduction to reading Avicenna's philosophical works*. Leiden: Brill,1988.

Gutas, Dimitri. *Greek Thought, Arab Culture: The Graeco-Arabic Translation Movement in Baghdad.* Florence,KY: Routledge, 1998.

Hall, Marie Boas “The Royal Society and Italy 1667-1795” in *Notes and Records of the Royal Society of London*. Vol.37/1. August, 1982.

Hartner, Willy. “The Astronomical Instruments of Cha-Ma-Lu-Ting, Their Identification, and Their Relations to the Instruments of the Observatory of Maragha” in *Isis* Vol.41/2. 1950.

Haskins, C.H. “Arabic Science in Western Europe” in *Isis* vol.7/3. 1925. pp. 478-485.

Haskins, C.H. “The Reception of Arabic Science in England” in *The English Historical Review* vol.30/117. 1915.

Henderson, G.P. “Greek Philosophy From 1600 to 1850” *The Philosophical Quarterly.* Vol.5/19. 1955.

Huff, Toby E. *The rise of early modern science : Islam, China and the West.* Cambridge : Cambridge University, 1995.

Hugonnard-Roche, H.. “The influence of Arabic astronomy in the medieval West” in *Encyclopaedia of Arabic Science*. London: Routledge, 1997.

Hutchison, K. "What Happened to Occult Qualities in the Scientific Revolution?" in *Isis*. vol.73/2. 1982.

Ibn Khaldun. *Muqaddimah*. tr. F. Rosenthal, ed. and abr. N. J. Dawood. Princeton: PUP, 1969.

İhsanoğlu, Ekmeleddin et al. *Osmanlı Astronomi Literatürü Tarihi.* İstanbul: IRCICA, 1997.

İhsanoğlu, Ekmeleddin. “The Introduction of Western Science to the Ottoman World: A Case Study of Modern Astronomy (1660-1860)” in *Transfer of Modern Science and Technology to the Muslim World: Proceedings of the International Symposium on ‘Modern Science and the Muslim World’*. Istanbul: IRCICA, 1992.

İhsanoğlu, Ekmeleddin. “Fatih Külliyesi Medresesi Ne Değildi!” in E.İhsanoğlu *Osmanlılar ve Bilim:Kaynaklar Işığında Bir Keşif.* Istanbul: Nesil, 2003

İhsanoğlu, Ekmeleddin. “Osmanlı Bilim Tarihi Konusundaki Araştırmalar Hakkında Bazı Notlar” in *Osmanlı Bilimi Araştırmaları*. İstanbul: İstanbul Üniversitesi Yayınevi, 1995.

İhsanoğlu, Ekmeleddin. “Ottoman Educational Institutions” in *Ottoman Civilization*. vol.1. ed. H.İnalcık & G.Renda. Istanbul: Ministry of Culture,2002.

İhsanoğlu, Ekmeleddin. “Ottoman Science in The Classical Period and Early Contacts with European Science and Technology” in *Transfer of Modern Science & Technology to the Muslim World.* Ed. E. İhsanoğlu Istanbul: IRCICA, 1992.

İhsanoğlu, Ekmeleddin. “The Initial Stage of the Historiography of Ottoman Medreses (1916-1965), The Era of Discovery and Construction” in E.İhsanoğlu. *Science, Technology and Learning in the Ottoman Empire.* Aldershot:Variorum, 2004.

İhsanoğlu, Ekmeleddin. “Batı Bilimi ve Osmanlı Dünyası: Bir İnceleme Örneği Olarak Modern Astronominin Osmanlı’ya Girişi(1660-1860)” in *Belleten* LVI/217. 1992.

İpşirli, Mehmet. “Lale Devrinde Teşkil Eden Tercüme Heyetine Dair Bazı Gözlemler” in *Osmanlı ilmi ve mesleki cemiyetleri : 1. milli Türk bilim tarihi sempozyumu, 3-5 Nisan 1987*. ed. Ekmeleddin İhsanoğlu. İstanbul : İstanbul Üniversitesi Edebiyat Fakültesi, İslam Konferansı Teşkilatı, İslam Tarih, Sanat ve Kültür Araştırma Merkezi, 1987.

İzgi, Cevat. *Osmanlı Medreselerinde İlim.* Vol.1 İstanbul: İz, 1997.

Kapp, A.G. “Arabische Übersetzer und Kommentatoren Euklids” in *Islamic Mathematics and Astronomy*, vol.19

Kaya, Mustafa. “Some Findings on Translations Made in the 18th Century from Greek and Es’ad Efendi’s Translation of the Physica” in *Transfer of Modern Science & Technology of the Muslim World.*

Kazancıgil, Aykut. *Osmanlılarda Bilim ve Teknoloji* Istanbul: Ufuk, 2000.

Kennedy, E.S. “Late Medieval Planetary Theory” in *Isis*. vol.57/3 (1966),

Kennedy, E.S. “The heritage of Ulugh Beg” in *Science in Islamic Civilization* Istanbul: IRCICA, 2000

King, David A. “Religion and Science in Islam I: Technical and Practical Aspects” in *Encyclopaedia of the history of science, technology, and medicine in non-western cultures*. ed. H. Selin. Dordrecht ; Boston : Kluwer Academic, c1997.

King, David A. “The Astronomy of the Mamluks” in *Isis* vol.74/4 1983

Korolec, J.B. “Islam Felsefesinin Krakovi Üniversitesi’nde Ele Alınışı” pp.131-145. in *Islam Felsefesinin Avrupa’ya Girişi* ed. Charles E. Butterworth & Blake A. Kessel, tr. Ömer Mahir Alper. İstanbul:Ayışığı Kitapları, 2001. orig. *The Introduction of Arabic Philosophy into Europe*. Leiden: Brill, 1994.

Kuhn, Thomas S. *The Copernican Revolution*. Cambridge: HUP, 1985 [1957]

Lindberg, David C. *The Beginnings of Western Science*. Chicago: UCP, 1992

Lloyd, G.E.R. “Saving the Appearances” in *Classical Quarterly*. Vol.28/1. 1978

Lloyd, G.E.R. *Greek Science After Aristotle*. New York: Norton, 1973.

Lohr, C.H. "Renaissance Latin Aristotelian Commentaries: Authors C" in *Renaissance Quarterly*. Vol.28/4: Studies in the Renaissance Issue. 1975

Makdisi, George. “The Reception of the model of the Islamic scholastic culture in the Christian West” in *Science in Islamic Civilization* Istanbul:IRCICA,2000.

McCluskey, S.C. *Astronomies and Cultures in Early Medieval Europe.* New York: CUP, 1998.

McConnell, A. “L.F.Marsigli’s Voyage to London and Holland, 1721-1722” in *Notes and Records of the Royal Society of London*. Vol.41/1. 1986

McKitterick, Rosamond. “Books and Sciences before print” in *Books and the sciences in history*. ed. M. Frasca-Spada and N. Jardine. New York : Cambridge University Press, 2000.

McMullin, Ernan. “Conceptions of Science in the Scientific Revolution” in *Reappraisals of the Scientific Revolution*. Ed. D.C. Lindberg and R.S. Westman. New York: CUP, 1990.

Meninski, Franciszek. *Thesaurus lingrarum orientalium turicae, arabicae, persicae: Lexicon Turcico-Arabico-Persicum.* [Mechanical Reprint] Istanbul: Simurg: 2000

Methuen, C. "Maestlin's Teaching of Copernicus: The Evidence of His University Textbook and Disputations" in *Isis* vol.87/2. 1996.

Monfasani, John. *Byzantine Scholars in Renaissance Italy: Cardinal Bessarion and other emigres: selected essays.* Aldershot: Variorum, 1995

Iorga, Nicolae. *Byzantium after Byzantium*. Tr. L. Treptow. Portland: Center for Romanian Studies, 2000.

Nasr, Seyyed H. *Science & Civilization in Islam,* 2nd ed. Cambridge : The Islamic Texts Society, 1987.

Neher, Andre. “Copernicus in the Hebraic Literature from the Sixteenth to the Eighteenth Century” in *Journal of the History of Ideas.* Vol.38/2. 1977.

Neugebauer, Otto. “The History of Ancient Astronomy Problems and Methods” in *Journal of Near Eastern Studies*. Vol.4/1. 1945.

Nev’î Efendi. *İlimlerin Özü: Netâyic el-Fünûn*. ed. Ö.Tolgay. İstanbul: İnsan Yayınları, 1995.

Newton, Isaac. *The Principia: Mathematical Principles of Natural Philosophy.* Tr. I.B.Cohen & A. Whitman. Berkeley, Los Angeles: University of California Press, 1999.

Pellat, Charles. “Les encyclopédies dans le monde Arabe” in *Etudes sur l'histoire socio-culturelle de l'Islam, 7e-15e siecles*. London: Variorum, 1976.

Pfeiffer, Rudolf. *History of classical scholarship : from 1300 to 1850.* Oxford : Clarendon Press, 1999.

Pines, Schlomo. “What Was Original in Arabic Science?” in *The Collected Works of Schlomo Pines*. Vol.3. Jerusalem: Magnes Press, 1986

Pingree, David. “Astronomy and Astrology in India and Iran” in *Isis* vol.54/2, 1963

Pingree, David. “The Greek Influence on Early Islamic Mathematical History” in *Journal of American Oriental Society.* Vol.93/1 1973

Piri Reis. *Kitab-ı Bahriye*. ed. Bülent Arı. Ankara: Undersecretaryship of Navigation, 2002.

Plutarch. “Life of Marcellus” in *The Lives of the Noble Grecians and Romans*. Chicago:Britannica, 1988.

Rabin, S.J. “Kepler’s Attitude Toward Pico and the Anti-Astrology Polemic” in *Renaissance Quarterly* vol.50/3. 1997.

Ragep, Jamil “Ali Qushji and Copernicus”, lecture delivered at ARIT, Jan 3, 2005

Ragep, Jamil. “Tusi and Copernicus: The Earth’s Motion in Context” in *Science in Context* vol.14/1. CUP, 2001

Randall, J.H. “The Development of Scientific Method in Padua” in the *Journal of the History of Ideas.* Vol. 1/2. 1940

Rattansi, P.M. “The Intellectual Origins of the Royal Society” in *Notes and Records of the Royal Society of London*. Vol.23/2.

Ravetz, J.R. “The Copernican Revolution” in *Companion to the History of Modern Science.* Ed. R.C.Olby, G.N. Cantor, J.R.R. Christie & M.J.S. Hodge. London: Routledge, 1990.

Reif, F. “The Textbook Tradition in Natural Philosophy, 1600-1650” in *Journal of the History of Ideas*, vol.30/1. 1969.

Rosenthal, Franz. *The Classical Heritage in Islam*. London:Routledge, 1994[1975]

Runciman, Steven. *The Great Church in Captivity*. Cambridge:CUP,1985.

Runciman, Steven. *The Last Byzantine Renaissance*. Cambridge: CUP, 1970.

Russell, Bertrand. *A History of Western Philosophy*. New York: Simon & Schuster, 1945

Saliba, George. "Arabic Planetary Theories after the Eleventh Century AD," *Encyclopedia of the history of Arabic science*. Vol.3 ed. by Roshdi Rashed in collaboration with Régis Morelon. London: Routledge, 1996.

Saliba, George. "The First Non-Ptolemaic Astronomy at the Maraghah School" in *Isis* vol.70/4. 1979.

Saliba, George. “"Writing the History of Arabic Astronomy: Problems and Differing Perspectives" in *Journal of the American Oriental Society*. vol.116/4. 1996

Saliba, George. “Arabic versus Greek Astronomy: A Debate Over the Foundations of Science” in *Perspectives on Science*. Vol.8/4. 2000.

Saliba, George. “Persian scientists in the Islamic world: astronomy from Maragha to Samarqand” in *The Persian presence in the Islamic world*. ed. R.G. Hovannisian and G. Sabagh. New York : Cambridge University Press, 1998.

Saliba, George. *A history of Arabic astronomy : planetary theories during the golden age of Islam.* New York : New York University, 1994.

Salih Zeki. *Âsâr-ı Bâkiye*. ed. R.Demir, Y. Unat and M.D.Gökdoğan Ankara: Babil,2003.

Sarı, N. and Zülfikar, M.B. “Paracelsusian Influence on Ottoman Medicine in the Seventeenth and Eighteenth Centuries” in *Transfer of Modern Science & Technology to the Muslim World.*

Sarıkavak, Kazım. *XVIII. Yüzyılda Bir Osmanlı Düşünürü: Yanyalı Esad Efendi.* Ankara : T.C. Kültür Bakanlığı, 1997.

Sarton, George. *The appreciation of ancient and medieval science during the Renaissance : 1450-1600.* 2nd ed. Philadelphia : University of Pennsylvania, 1955.

Sayılı, Aydın. “George Sarton and the History of Science” in *Belleten* XLVII/186. 1983.

Sayılı, Aydın. “Turkish Contributions to Scientific Work in Islam” in *Belleten* XLIII/172. 1979,

Sayılı, Aydın. *The Observatory in Islam.* Ankara : Atatürk Supreme Council for Culture, Languange and History Publications of the Turkish Historical Society, 1988.

Sayılı, Aydın. “Üçüncü Murad’ın İstanbul Rasathanesindeki Mücessem Yer Küresi ve Avrupa ile Kültürel Temaslar”in *Belleten* XXV/1961

Sayılı, Aydın. “Islam and the Rise of the Seventeenth Century Science”. in *Belleten,* XXII / 1958

Schramm, M. “Frederick II of Hohenstaufen and Arabic Science” in *Science in Context*. Vol.14/1-2. 2001.

Schubring, G. “Recent research on the institutional history of science and its application to Islamic civilization” in *Science in Islamic Civilization* Istanbul:IRCICA,2000.

Shapin, Steven. *The Scientific Revolution*. Chicago: UCP,1996.

Shelford, A.G. “Cautious Curiosity: Legacies of a Jesuit Scientific Education in Seventeenth-century France” in *History of Universities* vol. XIX/2 ed. M. Feingold. New York: OUP, 2004.

Smith, David E. “Euclid, Omar Khayyâm, and Saccheri” 1935, *Islamic Mathematics and Astronomy,* vol.19.

Solmsen, F. “Boethius and the History of the Organon” in *The American Journal of Philology*. Vol.65/1.

Stearns, R.P. “Fellows of the Royal Society in North Africa and the Levant, 1662-1800” in *Notes and Records of the Royal Society of London*. Vol.11/1. 1954.

Suter, Hinrich. *Beiträge zur Geschichte der Mathematik und Astronomie im Islam*. ed. Fuad Sezgin. Frankfurt : Institut für Geschichte der Arabisch-Islamischen Wissenschaften, 1986[1922].

Taşköprüzâde. *Mevz’uatü’l-ʿulûm*. İstanbul. h.1313.

Tekeli, Sevim. “Takiyüddin’in Sidret ül-Müntehasinda Aletler Bahsi” in *Belleten* XXV/15.

Tekeli, Sevim. *16. Yüzyılda Osmanlılarda Saat ve Takiyyüdin’in “Mekanik Saat Konstürsiyonuna Dair En Parlak Yıldızlar Adlı Eseri - The Clock in Ottoman Empire in 16th Century and Taqi al Din’s The Brightest Stars for the Construction of the Mechanical Clocks.* Ankara: T.C. Kültür Bakanlığı, 2002

Thorndike, Lynn. "The Survival of Mediaeval Intellectual Interests into Early Modern Times" in *Speculum.* vol.2/2 1927.

Thorndike, Lynn. "The True Place of Astrology in the History of Science" in *Isis,* vol.46/3. 1955.

Unat, Yavuz, ed. *Mir'atü'l-Alem: Ali Kuşçu'nun Fethiyye adlı eserinin çevirisi.* Ankara: Kültür Bakanlığı, 2001

Unat, Yavuz. "AÜ.D.T.C.F. Bilim Tarihi Anabilim Dalı" in *TALID* vol.2/4 2004

Unat, Yavuz. "Türk Astronomi Literatürü Tarihi 1923-2004" in *TALID* Vol.2/4 2004

Uzunçarşılı, İsmail Hakkı. *Osmanlı Devletinin İlmiye Teşkilâtı.* 3rd ed. Ankara: TTK, 1988.

Ünder, Hasan, ed. & tr. *Skolastik Eğitim ve Türkiye'de Skolastik Tarz: Salih Zeki, Yusuf Akçura, Muallim A. Cevdet.* Ankara: Epos, 2002

Ünver, A. Süheyl "İstanbul Muvakkithaneleri Vazifelerinin İlmi ve Kültürel Değerleri Üzerine in *Proceedings of the International Symposium on the Observatory in Islam.* ed. M. Dizer. Istanbul: 1977.

Ünver, A.Süheyl. *İstanbul Rasathanesi*. Ankara: TTK, 1969

van Helden, A. "Telescopes and Authority from Galileo to Cassini." in *Osiris, 2nd series.* vol.9

van Liere, K.E. "Humanism and Scholasticism in Sixteenth-Century Academe: Five Student Orations from the University of Salamanca" in *Renaissance Quarterly*. Vol.53/1. 2000.

Wallace, William A. *Prelude to Galileo*. Dordrecht : D.Reidel Publishing, 1981.

Westman, Robert. "The Melanchthon Circle, Rheticus, and the Wittenberg Interpretation of the Copernican Theory" in *Isis* vol.56/2. 1975.

Westman, Robert. "Two Cultures or One?: A Second Look at Kuhn's The Copernican Revolution" in *Isis*. vol.85/1. 1994.

Westman, Robert. "Proof, poetics and patronage: Copernicus's preface to De Revolutionibus" in *Reappraisals of the Scientific Revolution*. Ed. D.C. Lindberg and R.S. Westman. New York: CUP, 1990.

Wigner, Eugene. "The Unreasonable Effectiveness of Mathematics in the Natural Sciences," in *Communications in Pure and Applied Mathematics*, vol. 13, No. I. 1960.

Wilson, Curtis. "Kepler's Derivation of the Elliptical Path" in *Isis.* vol.59/1. 1968.

Wright, P. “Astrology and Science in Seventeenth-Century England” in *Social Studies of Science* vol.5/4. 1975.

Wright, Ramsay. “Über Die Schrift “Astronomica Quaedam” von Greaves. in *Islamic Mathematics and Astronomy,* vol.55.

Zetterberg, J.P. "Hermetic Geocentricity: John Dee's Celestial Egg" in *Isis* vol.70/3. 1979.