SCIENCE IN THE OTTOMAN EMPIRE

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The scientific activities observed within the borders of the Ottoman Empire throughout the six centuries of its history displayed a unique course of development. Although the Ottomans had shared many mutual elements with the other Islamic societies remaining outside of the Ottoman Empire, from the viewpoint of historical heritage and tradition, they also had some differences due to the geographical location, administration of the state and the dynamism of the society. Thus, Ottoman science had an innovative attribute from the viewpoint of the developments experienced, even though it shared a lot with the Islamic world outside the Ottoman lands from the aspect of its sources. Ottoman scientific tradition was initially formed under the influence of the experience of the earlier Islamic centers of science and culture. However, after a short period of time, Ottoman science reached a point where it could influence the old centers of science and culture and serve as an example to them. On the other hand, this innovative character of the Ottomans was emphasized by the fact that as of the seventeenth century the influences of Western science gradually appeared in the Ottoman world and began to influence the other Islamic countries. These developments brought the Ottomans, who represented the Islamic world as a whole, to a point of constituting a unique synthesis between Islam and the modern West.

The great changes in the scientific and educational life of the Ottomans had been realized within an extensive time span. Consequently, it is difficult to connect the radical changes in Ottoman history to specific events or to start as of a certain date. In general, "old and new" were together and existed in parallel with each other. On this subject it will be attempted to set forth analytically the outline of the two stages of Ottoman science. At the same time, the subject of the formation and development of the classical Ottoman tradition of science that was based on the Islamic tradition of science prior to the Ottomans and especially based on the

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heritage of the Seljuks will be briefly discussed. However, the Ottoman scientific tradition also developed with the contributions made from outside the Empire and the relevant aspects of the Western scientific tradition, which developed as the result of close relations with the West. In this chapter, the works in languages other than Turkish, Arabic and Persian written by scholars from the non-Moslem population composed of the Greeks, Armenians, Bulgarians, Serbians, Hungarians and Romanians who were members of the Christian sects and Jews living in the Asian and European territories of the Empire and the scientific activities occurring in these cultural circles will not be considered. The reason for this is that at present the studies related to Ottoman science have not reached an intensity, which would assist in considering this subject in a satisfactory manner. It is without a doubt that the general and comprehensive evaluations related to Ottoman science certainly will become perfected with the consideration of these aspects as well which have not drawn much attention or been given the degree of interest they deserve[1].

The Classical Ottoman Scientific Tradition and Institutions

Ottoman science was established on the scientific heritage of the previous Seljuk State and on the foundation of the educational and scientific institutions that were established in the Anatolian cities in that period. Furthermore, the Ottomans also benefited from the activities of the scholars from the most advanced cultural and scientific centers of the period such as in Egypt, Syria, Iraq, Iran and Türkistan (Turkestan). The Ottomans protected and enriched the cultural and scientific heritage of the Islamic world and brought to it a new dynamism and vitality. Thus, besides the old centers of Islamic civilization, new cultural and scientific centers emerged such as in Bursa, Edirne, Istanbul, Skopje and Sarajevo. The Ottoman culture and science that developed during this period constituted the cultural identity and scientific heritage of the present-day Turkey and as well as for many of the Middle Eastern, North African and Balkan countries.

In the classical period, the *medrese* (in Arabic *madrasa* “college”) was the source of education and science and the most important institution of learning in the Ottoman Empire. The Ottoman medreses continued their activity from the time

[1] For the history of Ottoman science in general see E. İhsanoğlu, "Osmanlı Eğitim ve Bilim Müesseseleri" (Ottoman educational and scientific institutions), 223-361, in Osmanlı Devleti ve Medeniyeti Tarihi (The history of the Ottoman state and civilization), vol. 2 (Istanbul, 1998); for the Arabic of the same chapter see E. İhsanoğlu, "el-Müessesât el-Ta'lîmiyye ve'l-İlmiyye inde'l-Osmâniyyîn", 441-598, in *el Devlet el-Osmâniyye Tarih ve Hadara*, vol. 2 (Istanbul, 1999) (the English version of this book is being printed); and A. Adnan Adıvar, *Osmanlı Türklerinde ilim* (Science in the Ottoman Turks), (Istanbul, 1982); for a general summary see E. İhsanoğlu, "Osmanlı Bilimi" (Ottoman science), 21-38, in *Büyük Cihad'dan Frenk Fodulluğuna* (From the great holy war to the European presumptuousness), (Istanbul, 1996; for the English of the same chapter see "Ottoman Science", in *Encyclopaedia of the History of Science, Technology and Medicine in Non-Western Cultures*, ed. Helaine Selin (Dordrecht: Kluwer Academic Publishers, 1997), 799-805.

of the foundation of the State until approximately the turn of the twentieth century. The basic structure of the medreses remained the same within the framework of the Islamic tradition, but in terms of organization they underwent several changes during the Ottoman period. Starting with the first medrese, established in 1331 in Iznik (Nicaea), all medreses had *waqfs* (charitable foundations) supporting their activities.

Besides the *ulemā* (scholars who were medrese graduates) that provided religious, scientific and educational services, the medreses also trained the personnel for administrative and bureaucratic posts and the courts. Those ulema who were members of the *ilmiye* (Muslim learned, cultural, and religious institution) also played an important role in every aspect of the social and official life. With the reign of Mehmed II (Fatih, known as the Conqueror, 1451-1481), the number of medreses increased considerably and they were graded to differentiate them from each other.

Shortly after Mehmed II conquered Istanbul in 1453, he built the Fatih *Külliye* (complex) which comprised a mosque at the center with other units located around it, also colleges, one hospital, one *mektep* (primary school), one public kitchen. It set an example for similar institutions that were built by the succeeding sultans and high-ranking members of the ruling class. The structure of an integrated campus was represented by the *Sahn-ı Semān Medreses* (Eight Court Colleges) of the Fatih Complex that comprised sixteen adjacent medreses. Owing to the political stability and economic prosperity of the Conqueror's period, distinguished scholars and artists of the Islamic world assembled in the capital of the Empire. The Ottomans especially protected the Muslim and Jewish scientists fleeing from the persecution that followed the fall of Granada in 1492 and provided them with shelter in the Ottoman lands. Moreover, as the waqfs which were the financial sources of medreses grew rich, scientific and educational life developed further. Following the establishment of the eight court medreses by Mehmed II, the rational sciences comprising mathematics and astronomy, were included in the formal educational system.

The medrese graduates served as teachers, *qādīs*, *kazaskers* (chief judges) and chief *muftis*. Several physicians were trained and many patients were treated in the *daruşşifa* (hospital) of Fatih Complex which was active until the middle of nineteenth century. The Fatih Complex provided services to the society in the fields of religion, education, science and health, as well as offering food to the needy in its public kitchens. As of the second half of nineteenth century, the Fatih Complex gradually became ineffective, its various units, namely the hospital, *tābhāne* (hospice), *muvakkithāne* (office of the timekeeper), caravanserai and the primary school stopped operating. Finally, after all the medreses were discontinued in the Republican Period in 1924, its colleges, too, were closed down. The mosque,

however, continues its principal function from the time of its establishment until the present day.

The establishment of the Süleymaniye Külliye by Süleyman the Magnifīcent (1520-1566) in the sixteenth century marked the final stage in the development of the medrese system where, besides the conventional medreses, a specialized (Medical College) *Dārüttıb* was founded. Thus, for the first time in Ottoman history, in addition to the *şifahānes* (hospitals), an independent institution was established to provide medical education. The other specialized medreses established by the Ottomans were the *Dārülhadīs* and the *Dārülkurrā. Dārülhadīs* held the highest grade in the medrese hierarchy.

In addition to the medreses, there were institutions where medical sciences and astronomy were practiced and taught by the master-apprentice method. These were the şifahānes, the muvakkithānes and the office of the *müneccimbaşı* (chief astronomer of the sultan).

The institutions which provided health services and medical education were called *dārüşşifa, şifahāne* or *bīmāristan.* The Seljukids had built *dārüşşifas* in the cities of Konya, Sivas, and Kayseri. Similarly, the Ottomans built several dārüşşifas in cities such as Bursa, Edirne, and Istanbul. Some Western sources mention that in Istanbul they were numerous in number in the sixteenth and seventeenth centuries, which is an indication of the importance attributed to them. The Ottomans constructed the hospitals on which they placed great importance as a unit of the külliye (complex of buildings attached to a mosque) to provide for their continuity, rather than as independent buildings. The Fatih Hospital founded by Sultan Mehmed the Conqueror in 1470, the Bayezid Hospital founded in Edirne in 1481 with an order from Sultan Bayezid II, the Sülemaniye Hospital established in 1550, the Haseki Hospital (1550) founded in the same period and the Hafsa Sultan Hospital (1522-1523) established in Manisa by Hafsa Sultan, the wife of Sultan Selim I, are some of these types of important structures. These hospitals, besides treating patients, also had an important place in the education of doctors and continued their activities until the opening of modern hospitals around the middle of the nineteenth century. '

The timekeeping houses are another of the Ottoman institutions related to science. They were constructed in the courtyard of some mosques in the cities and towns as a component of the *külliye*s, especially after the conquering of Istanbul. They maintained their activities with the revenues of the charitable foundations of the *külliye*. The muvakkit (timekeeper) was responsible for determining prayer times. They used instruments such as the quadrant, astrolabe, sextant, octant, sundials and mechanical clocks with chronometers. The timekeeping houses, besides teaching the knowledge of timekeeping, have also been institutions where mathematics and astronomy were taught.

In addition to the institutions mentioned above which were supported by their own special charitable foundations, there were two other state institutions. One was the office of chief physician and other was office of the chief astronomer. The chief physician and chief astronomer were selected from among the ulema class of scholars who were well educated.

The chief physician provided health services for the sultan and his family and the members of the palace; they were also responsible for all the institutions related to health and for the doctors, pharmacists, surgeons and ophthalmologists in the Empire. A total of forty-two persons have been appointed to this position, some of them more than once, until the termination of office of the chief physician in 1844.

The office of the chief astronomer was established towards the end of the fifteenth century. The chief astronomer's most important duty was the preparation of calendars. Until the year 1800, calendars were based on Ulug Bey's Astronomical Tables and henceforth according to Cassini's Astronomical Tables. Astronomers were responsible for determining the beginning of fasting times *[imsakiye]* before the month of Ramadan and preparing horoscopes *[zayije]* and astronomical tables *(Zics)*. Astronomers and occasionally their assistants would be responsible for determining propitious times such as dates of accession to the throne and declaration of war and launching of ships, and for special occasions such as births, weddings and circumcisions.

The astronomer would interpret horoscopes of the sultan and his family, and statesmen, and when his interpretations came true, gifts would be bestowed upon him. Astronomers would also follow important astronomical events such as comets, earthquakes, fires and eclipses of the sun and the moon and other extraordinary events and would submit their interpretations to the palace. They were also responsible for the management of timekeeping houses. The famous observatory founded in Istanbul during the reign of Murad III (1574-1595) was under the management of Chief Astronomer Takiyeddin el-Rasid (d. 1585). A total of thirty-seven scholars undertook the position of chief astronomer up until the end of the Ottoman Empire. This institution was abolished in 1924 after the proclamation of the Republic and in its place the *bashmuvakkitlik* (office of the chief timekeeper) was established in 1927

In addition to the scientific activities that centered around the madrasas, other active and dynamic scholarly environments were developed around the above-mentioned institutions, such as the Suleymaniye Medical Madrasa", "office of the chief physician and the chief astronomer, and timekeeping houses. Many works produced in the classical period were prepared within the milieu of these institutions.[2]

[2] For general information see E. İhsanoğlu, "Osmanlı Eğitim ve Bilim Müesseseleri", 254-270; for the institution of the Chief Physician see Ali Haydar Bayat, *Osmanlı Devleti'nde Hekimbaşılk*

Establishment of the Istanbul observatory

Takiyeddin el-Rasid, was born in Damascus and educated in Syria and Egypt. He came from Egypt to Istanbul in 1570 and was appointed as the chief astronomer by Sultan Selim II. Takiyeddin started the construction of an observatory in Istanbul with the order of Murad III, who had ascended the throne in 1574. The observatory was designed to provide for the needs of the astronomers and included a library and lodgings. This institution was conceived as one of the largest observatories in Islam and completed in 1579. It was comparable to Tycho Brahe's Uranienborg observatory built in 1576. There is a striking similarity between the instruments of Tycho Brahe and those of Takiyeddin. In his astronomical tables called *Sidratu Muntehe'l Efkar* (The Lotus Tree of the Extremity of Thoughts) Takiyeddin states that he started activities on astronomy in Istanbul with fifteen assistants in 1573. The observatory continued to function until 22 January 1580, the date of its destruction.[3]

Takiyeddin, who developed a new method for the calculation of the solar parameters with his studies at the Istanbul Observatory, used the planet Venus and the two stars named Aldebaran and Spica Virginis for the determination of the longitudes and latitudes of fixed stars. He determined the ecliptic degree as 23° 28' 40", which is very close to the current value of 23" 27'. He used a new method in calculating solar parameters as well as determining the magnitude of the annual movement of the sun's apogee as 63 seconds. Considering that today's known value is 61 seconds, the method he used appears to have been more precise than that of Copernicus (24 seconds) and Tycho Brahe (45 seconds).

The Western world used chords for the measurement of angles beginning with Ptolemy from the second century AD up until Copernicus in the sixteenth century. Consequently, the calculation of a 1° chord was one of the important problems of the astronomers. Copernicus used a method based on the calculation of a 2° chord that yielded an approximate value, whereas, Takiyeddin did not use chords in the measurement of angles. Instead, he used the trigonometric functions such as sine, cosine, tangent and cotangent in conformity with the tradition of Islamic astronomy. He developed a different method to calculate the sine of 1° as inspired

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Kurumu ve Hekimbaşılar (The institution of chief physician in the Ottoman state and the chief physicians), (Ankara, 1999); for the institution of Chief Astronomer see Salim Aydüz, *Osmanlı Devleti'nde Müneccimbaşılık ve Müneccimbaşılar* (The institution of chief astrologer in the Ottoman state and the chief astrologers), (Master's thesis, Istanbul University, Faculty of Literature, 1993); for Hospitals see E. Ihsanoğlu, "Osmanlı Eğitim ve Bilim Müesseseleri", 259-263; for Muvakkithanes see Süheyl Ünver, "Osmanlı Türkleri İlim Tarihinde Muvakkithâneler" (Muvakkithanes in history of science of the Ottoman Turks), 217-257, in *Atatürk Konferanslan,* V, offprint from 1971-1972 (Ankara, 1971).

[3] For Observatory see Aydın Sayılı, *The Observatory in Islâm and its Place in the General History of the Observatory* (Ankara, 1960); İsmet Miroğlu, "İstanbul Rasathânesi'ne Ait Belgeler" (Documents related to the İstanbul observatory), *Tarih Enstitüsü Dergisi*, 3 (October 1972): 75-82.

by Uluğ Bey. Rather than using the number system based on the sexagesimal base for the calculations and precision of his astronomical observations, he applied the decimal fractions to trigonometry and astronomy that were previously developed by the Islamic mathematicians such as el-Öklidisi and Giyaseddin Jamshid el-Kashi (d. 1429) and prepared sine and tangent tables in his work called *Ceridetu'd Durer ve Kharidetu'l Fiker.*

Takiyeddin invented new instruments that were added to the array of those already in use for observation purposes in the Islamic world. The following were among the instruments he used: 1} an armillary sphere known to be invented by Ptolemy; 2) a mural quadrant; 3) an azimuthally quadrant 4) a parallel ruler; 5) a ruler-quadrant or wooden quadrant; 6) an instrument with two holes for the measurement of apparent diameters and eclipses; 7) an instrument with chords to determine the equinoxes, invented by Takiyeddin to replace the equinoctial armillary, 8) *Muşabbaha bi'l-menatık,* another of his inventions, the nature and function of which is not clearly explained; 9) a mechanical clock with a train of cogwheels 10) a *sunaydi* ruler, apparently a special type of instrument of an auxiliary nature, the function of which was explained by Alaeddin el-Mansur. Takiyeddin used a mechanical clock of his own make, as well as a wooden wall dial that he set up in the observatory. He described the clock as: "we built a mechanical clock with a dial showing the hours, minutes and seconds and we divided every minute into five seconds." This was a more precise clock than those previously used and considered to be one of the significant inventions in the field of applied astronomy developed during the sixteenth century.[4]

Takiyeddin prepared a solar astronomical table called *Sidratu Muntehe'i Efkar ft Melekuti'l Feleki'd-Dewar* or *Zic-i Şehinşahî* based on his observations at the Observatory and dedicated it to Sultan Murad III. His other book *Ceridetu'd Durer ve Haridetu'l Fiker* contains the lunar tables.

He examined the writings of the ancient astronomers and added a critique of his previous works on astronomy to the new elements he developed. Undoubtedly his studies formed the apogee of Ottoman science while his activities after the foundation of the Istanbul Observatory provided the most advanced development in the tradition of Islamic astronomy. The destruction of the observatory as a result of the competition and jealousy among the statesmen under religious pretexts was considered to be the beginning of the halting of the tradition of the classical Ottoman science.[5]

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[4] See Aydın Sayılı, *The Observatory in Islam and its Place in the General History of the Observatory*, (Ankara, 1960), 300.

[5] For an evaluation of Takiyeddin's works see Sevim Tekeli, "Nasirüddin, Takiyeddin ve Tycho Brahe'nin Rasad Aletlerinin Mukayesesi" (A comparison of the instruments of observation of Nasirüddin, Takiyeddin and Tycho Brahe), *Ankara Üniversitesi Dil ve Tarih Coğrafya Fakültesi Dergisi* 21:3-4 (1958), 301-393; Sevim Tekeli, *16'ıncı Asırda Osmandılar'da Saat ve Takıyüddin'in,*

The Ottoman Scientific Literature of the Classical Period

Scientific literature of the classical period is composed of a significant number of original studies and translated works, the great majority of which were textbooks written mainly in the fields of astronomy, mathematics and medicine. Only a few of the works have been studied today, which were written in the three languages known as *elsine-i selase*, that is, Arabic, Turkish and a small number in Persian, which were generally well known by the Ottoman scholars.[6]

Initially, the works of Ottoman scientific and educational literature were generally written in Arabic which was the basic language of Islamic civilization. Furthermore, as of the fourteenth and fifteenth centuries, works written in Arabic and Persian were translated into Turkish, thus a translation movement was started. This movement spread with enthusiasm by the formation of a wider group of readers who found the opportunity to read the translated works and also with the support of the administrators of the period who did not know Arabic very well. Translations were made in simple and easily understandable Turkish in every field of Islamic sciences (medicine, astronomy, pharmacy, geography, encyclopedic books, dictionaries, interpretation of dreams and music) and were instrumental in the spread of Islamic culture among the people. Original Turkish works were also written. Starting from the beginning of the eighteenth century and specifically after the printing of the first book at the Müteferrika Printing House in 1729, the majority of the scientific books were prepared in Turkish. Ottoman Turkish became the basic language frequently used in the transfer of modern sciences both to the students of new institutions of learning and to the public.

'Mekanik Saat Konstrüksiyonuna Dair En Parlak Yıldızlar" Adlı Eseri (Clocks in the Ottomans in the sixteenth century and Takiyeddin's work called "The brightest stars concerning the construction of mechanical clocks"), (text in Turkish-English-Arabic), (Ankara, 1966); Sevim Tekeli, "Takiyeddin'de Güneş Parametrelerinin Hesabı" (Calculation of the solar parameters by Takiyeddin), 703-706, in *Necati Lugal Armağanı,* (Ankara, 1968); Sevim Tekeli, "Onaltıncı Yüzyıl Trigonometri Çalişmaları Üzerine Bir Araştırma: Copernicus ve Takiyeddin" (A research on the sixteenth century trigonometry studies: Copernicus and Takiyeddin), *Erdem,* 2:4 (1986): 219-272; Sevim Tekeli, "Taqi al-Din", 934-935, in *Encyclopaedia of the History of Science Technology and Medicine in Non-Western Cultures*, ed. Helaine Selin (Dordrecht: Kluwer Academic Publishers, 1997); and Remzi Demir, *Takiyeddin'in Ceridet el Dürer ve Haridet el Fiker Adh Eser ve Onun Ondalik Kesirleri Astronomi ve Trigonometriye Uygulaması,* (Takiyeddin's work called Ceridet el Dürer ve Haridet el Fiker and his application of decimal fractions in astronomy and trigonometry) (Ph.D. diss., Ankara University, Faculty of Language, History and Geography, 1992).

[6] For a general description of Ottoman scientific literature see E. İhsanoğlu, "Osmanli Bilimi Literatürü" (Ottoman scientific literature), 363-444, in *Osmanlı Devleti ve Medeniyeti Tarihi* (The history of the Ottoman state and civilization), vol. 2 (Istanbul, 1998); for the Arabic of the same chapter see E. İhsanoğlu, "Edebiyât el-Ulûm mde'1-Osmâniyyîn", 601- 689, in el *Devlet el-Osmâniyye Târih ve Hadara,* vol. 2 (Istanbul, 1999) (the English version of this book is in print); for a general summary of this subject see "Ottoman Science in the Classical Period and Early Contacts with European Science and Technology", 1-48, in *Transfer of Modern Science and Technology to the Muslim World,* (Istanbul, 1992).

To get an overview of the scholarly life in the Ottoman Empire until the time of Suleyman I, an analytical study of the biographical dictionary of Taşköprülü-zade İsameddin Ahmed b. Mustafa (1495-1561) titled *Şakayiku'n-Numaniye fî Ulemai'd-Devlet'l-Osmaniye* is made, dealing with Ottoman scholars and Sufis who lived during the reigns of the first ten Ottoman sultans. Accordingly, in that period the proportional distribution of works authored by Ottoman scholars is as follows: 25.7% rational sciences, 25.7% history-literature-ethics, 22.8% exegesis, 14.2% jurisprudence, 8.5% Sufism, 2.8% creed. As for commentaries and translations written by Ottoman scholars on works authored in pre-Ottoman times, the distribution is as follows: 26.6% jurisprudence, 20.8% rational sciences, 15.8% theology, 13.5% history-literature-ethics, 9.5% creed, 8.5°/o exegesis, 2.7% Sufism and 2.2% hadith.[7] These figures correspond to the first 250 years of Ottoman cultural and scholarly life and display clearly the areas of concentration. Taşköprülü-zade who gave information on jurisprudence, hadith, theology, literature and history produced 20 works.

Kadizade-i Rumi (d. ca. 1432) of Bursa, one of the famous Ottoman scholars, made numerous contributions to the development of Ottoman scientific tradition and literature. Kadizade, who wrote his first work in Anatolia where he started his scientific career, later moved to Samarkand. Among his works, the commentary titled *Şerhu Mulahhas fi'l Hey'e* (Commentary on the 'Compendium on Astronomy') which he wrote on the astronomy book of Çağminî *el Mulahhas fi'l Hey'e* (Compendium on Astronomy) and his book named *Şerhu Eşkalu't-Te'sis,* a commentary on Semerkandî's *Eşkalu't-Te'sis* on the subject of geometry are among his well-known works. Kadizade was appointed as head of the Samarkand Observatory and Madrasa which was founded by Uluğ Bey (d. 1449). He contributed to the preparation of the famous Uluğ *Bey Zici (Zîc-i Gurganî)* (Astronomical tables of Ulug Bey) which is in Persian. Another of his famous books on mathematics is the treatise called *Risaie fi Istihraci Ceybi Derece vahide bî Amâlin Müessetin alâ Kavâidin Hisabiye ve Hendesiye alâ Tarikati Giyaseddin el-Kaşî.* As will be understood from the title, this treatise is an explanation about the algebraic method developed for the calculation of the sine of a one-degree arc by Jamshid el Kashî. Scholars such as Ali Kuşçu (d. 1474) and Fetullah Şirvanî (d. 1486), who were trained by Kadizade in Samarkand, came to the Ottoman lands from Turkestan and made significant contributions to the development of Ottoman science.

It is understood that the works of Kadizade of Bursa called *Şerhu Mulahhas fi'l Hey'e* (Commentary on the 'Compendium on Astronomy') and *Şerhu Eşkalu't-*

[7] M. Hulûsi Lekesiz, "*Osmanli İlmi Zihniyetinde Değişme (Teşekkül-Gelişme-Çözülme: XV-XVII. Yüzyıllar)*", (Changes in the Ottoman scientific mentality {formation-development-disintegration: XVth-XVIIth centuries}), (Master's thesis, Hacettepe Univ. Faculty of History, 1989).

Te'sis were basic textbooks for the students who wanted to study these two sciences at the Ottoman madrasas. More than three hundred copies of the first work and about two hundred of the second survived until the present day. When the colophons of the copies of both of these works are examined, it is understood that they were not taught only in the Ottoman world, but also in the madrasas of other Islamic countries outside the administration of the Ottoman State such as Iran, Central Asia, India and Morocco. The colophons of these copies extending from the fifteenth century up until the twentieth century indicate that they were the basic textbooks used for almost five centuries in the Ottoman and generally in the Islamic world.[8]

In the introduction of his work titled *Şerhu Eşkalu't-Te'sis,* Kadizade-i Rumi (d. after 1440) states that "philosophers who ponder over the creation and secrets of the universe, jurists *(fakihs)* who give legal opinions *(fetvas)* on religious matters, officials who carry out state affairs and *(kadis) judges* who deal with legal matters should know geometry" He indicates the need for mathematical and natural sciences in philosophical, worldly and spiritual matters. This scientific understanding expressed by Kadizade-i Rumi constitutes the basic thinking of Ottoman scholars and reflects the character of classical Ottoman science until the modernization period. Ottoman scholars of the modern period were not familiar with the European concept of science and technology that was centered on the idea of "taking nature under the control of human beings by means of science and technology".

Among other books of astronomy in this period, the works of Abdulvahab b. Cemaleddin b. Yusuf el Mardanî called *Urcuze fi Menazili'l Kamer ve'l Tuluiha* (Poem on the Mansions of the Moon and their Rising) and *Mazume ft Silk el Nücum* (Poem on the Orbits of the Stars) written in Arabic should be mentioned. Furthermore, there are two works called *Risale Muhtasara fi'l Takvim* (Brief Treatise on the Calendar) and *Si Fasl fi'l Takvim* (Thirty Sections on the Calendar) written in Persian by Nasireddin Tusî, founder of the Maragha school of astronomy. Probably the first title and definitely the second one was translated from Persian to Turkish by Ahmed-i Daî (d. 1421). He stated that the translations were made for the beginners who wanted to study this science. This and other conjectures similar to these show that the Turkish language was used, though gradually, as a language of education and science in Anatolia and at the same time in the Ottoman territories.

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[8] For Kadızâde's work called *Şerhu'l Mülahhas fi'l Hay'a* (Commentary on the Compendium on Astronomy), the existing copies and studies on this work see E. İhsanoğlu, Ramazan Şeşen, et al., TOsmanlı Astronomi Literatürü Tarihi (The history of Ottoman astronomy literature), vol. l, (Istanbul, 1997), 8-21; for Kadızâde's work called *Şerhü'l Eşkâlü't-Te'sîs* see E. İhsanoğlu, Ramazan Şeşen and Cevat İzgi, *Osmanlı Matematik Literatürü Tarihi* (The history of Ottoman mathematics literature), vol. l, (Istanbul, 1999), 6-18.

In addition to Samarkand, Egypt also constituted another source for Ottoman science in the period of the formation of scientific literature. Hacı Pasha (Celaleddin Hızır) (d. 1417), famous Ottoman physician who was educated in Egypt, wrote a medical book in Turkish called *Kitabu'l Teshil f!'t-Tip* (Book Facilitating the Learning of Medicine) and two works in Arabic called *Şifa el Askam* ve *Deva el Alam* (Treatment of Illnesses and Cure for Pains) and *Kitab el Talim fl't-Tibb* (Book on the Teaching of Medicine). Hacı Pasha, in addition to his numerous works in Turkish and Arabic, made significant contributions to the development of Ottoman medical sciences with these two books.

The works written by Şerefeddin Sabuncuoğlu (d. ca. 1468) on the subject of medicine have an important place in the development of Ottoman medical literature. His first Turkish work on surgery called *Cerahiyyetü'l Haniyye* (Treatise on Surgery of the Sultans) is composed of the translation of the section on surgery from the general medical book named *el-Tasrif* by Ebu'l Kasim Zahrawî (d. 1013), the famous Andalusian physician and surgeon, and three sections which he wrote himself. In the translation, surgical instruments were depicted in miniatures as in the original work. The work, in addition to the classical Islamic medical knowledge, reflects the influences of Turkish-Mongolian and Far Eastern medicine as well as the author's own experiences. The influence of Sabuncuoğlu was observed outside the Ottoman borders and specifically in Safavid Iran, in particular through his student Giyas b. Muhammed İsfahanî. The most important characteristics of this work that attained a great fame in world medical history is that surgical operations are depicted in miniature paintings. [9]

Mehmed II, who took Muslim scholars under his patronage, was also interested in ancient Greek culture and the newly developing culture in the West. He instructed Georgios Amirutzes, a Greek scholar from Trabzon and his son to translate Ptolemy's geography book into Arabic and to draw the world map. The Sultan's interest in European culture began in Manisa where he resided as a prince. In 1445 he took lessons on Roman and European history from Italian humanist Ciriaco d'Ancona and other Italian scholars; had his portrait painted by Gentile Bellini and the walls of the palace decorated with frescoes in the Renaissance style. Greek Patriarch Gennadious wrote the *İtikadname* for him, describing the Christian belief. Both Francesco Berlinghieri and Roberto Valturio wanted to present their works to the Sultan titled respectively *Geogrophia* and *De re Militari* (Verona, 1492) (a copy of this work is in the Topkapı Palace Museum Library). G. Stefano Emiliano, one of the humanists in his court, wrote an elegy when Mehmed II died. [10]

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[9] İlter Uzel, *Şerefeddin Sabuncuoğlu Cerrâhiyyetü'l Hâniyye* (treatise on surgery of the sultans), 2 vols. (Ankara, 1992).

[10] Halil İnalcık, "Mehmed II" *İslam Ansiklopedisi*, vol. 7, 535.

Examples of his patronage of Muslim scholars are seen in the encouragement given to Hoca-zade and Alaeddin el-Tusî in writing works in their own fields of expertise and in his instructions asking them to make comparisons between Gazali's *Tehafut el-Falasife* (Criticism of the Philosophers), a work criticizing the views expressed on metaphysical events by philosophers who were members of the Aristotelian tradition, and the book *Tehafutd-Tehafut* (The Criticism of the Criticism) written by Ibn Rushd as a response to Gazali's work.

Undoubtedly, the most noteworthy scholar of the Mehmed II period is Muhammed b. Ali, the representative of Samarkand tradition, who is better known by the name of Ali Kuşçu. He wrote twelve books on the subjects of astronomy and mathematics. One of these is the commentary in Persian on the Uluğ Bey Zîç (The Astronomical Tables of Ulug Bey). The *Risale fi'l Hey'e* (Treatise on Astronomy) written in Persian and the *Risale ft'l Hisab* (Treatise on Arithmetic) on the subject of arithmetic can be mentioned among his other important works. He rewrote these works with some additions in Arabic under the names of *el Fethiye* and *el Muhammediye,* in honor of Mehmed II, which were used as textbooks for many years at the Ottoman madrasas.

Another noteworthy personality was Molla Lütfü, one of the scholars who lived during the reign of Sultan Bayezid II (1481-1512). He wrote a treatise in Arabic called *Mevzuatu'l Ulum* (Subjects of the Sciences) on the subject of the classification of sciences and a work called *Tadif al-Mazbah* (Duplication of the Cube) which was partly translated from Greek on the subject of the Delos problem in geometry.

Another famous astronomer and mathematician of the same period is Mirim Celebi (d. 1525), grandson of both Kadızade (from his son) and Ali Kuşçu (from his daughter). He made great contributions to the development of Ottoman scientific tradition in the fields of astronomy and mathematics with the commentary he wrote on the *Zic-i Uluğ Bey* and his treatises on astronomy.

The Muslim and Jewish scholars who came from Andalusia made another interesting contribution that was discovered recently in the Ottoman scientific literature. Iliya b. Abraham of Andalusia, who came to Istanbul during the reign of Bayezid II, is one of these scholars. This scholar, who took the name of Abdüsselam el Muhtedî el-Muhammedi after he converted to Islam, wrote books on astronomy and medicine in Arabic. In his book originally written in Hebrew, which he translated into Arabic in 1503 and dedicated to Bayezid II, he mentions an instrument of astronomy of his own invention which he called *ei-Dabid* that is larger than the *Zatu'l halak* (armillary sphere) made by Ptolemy. This book reveals an aspect of the Ottoman scientific literature that is still not very

well known.[11] There were also quite noteworthy developments in the scientific literature during the reign of Süleyman I. We encounter two significant works in Turkish in this period written by Matrakçı Nasuh called *Cemâlü'l Küttâb ve Kemâlü'l Hussâb* (Grace of Scribes and Accuracy of Accountants) and *Umdetü'l Hisab*(Treatise on Arithmetic). Furthermore, Taşköprülü-zade İsameddin Ebu'l-Hayr Ahmed b. Mustafa (1495 Bursa - 1561 Istanbul), who wrote works on the subject of the classification of sciences in the Ottomans during the classical period, was at the same time one of the most important biographers of the period who gave information on the cultural and scientific life of the Ottomans. He produced twenty works on the subjects of Islamic jurisprudence, hadith, theology, literature and history. Besides this work, Taşköprülü-zade has a book of the classification of sciences called *Miftah el Saade ve Misbah el Siyade* (The Key to Happiness and the Light of Supremacy) or briefly and widely known as the *Mevzu'ât el Ulûm* (Subjects of the Sciences) and another book of biographies called *Nevadir el Ahbar fî Menakib el-Ahyar* (The Rarity of News on the Legends of the Good and Virtuous).

The classical scientific tradition that produced its finest works in the most magnificent period of the Empire was set forth in the scientific and educational institutions that are briefly mentioned above and in the scholarly circles established and developed around these institutions. This tradition, preserved its continuity during the second phase of Ottoman science i.e., during the stage where translations and transfers were made from European languages and was able to survive with some of its basic elements until the second half of the nineteenth century.

First contacts with the European "science", transfers and translations

The fact that the Ottoman Empire was also a European country and had common borders with the Western European countries, had been influential in making the Ottomans the first country outside the Western world where Western science and technology was spread and provided the Ottomans with an awareness of the new explorations and inventions appearing in Europe. This relationship, which was formed within a selective process of transfer, characterizes the nature of the Ottomans' attitude vis a vis the Western science and technology and their attitudes towards these innovations developing in Europe. The adoption of these innovations by the Ottomans differed from those of the Russians, Chinese and Japanese. Also, it does not conform to the theories of

[11] For the scholars who came from Andalusia and their contributions see E. İhsanoğlu, "Endülüs Menşe'li bazı Bilim Adamlamun Osmanlı Bilimine Katkıları" (The contributions to Ottoman science of some scholars of Andalusian origin), 85-137, in *Büyük Cihad'dan Frenk Fodulluğuna* (From the great holy war to the European presumptuousness), (Istanbul, 1996).

"central-peripheral" and "exploiter-exploited" interpretation of the spreading of Western science outside its cultural environment.[12] The attitudes of the Ottomans towards Western science and technology are interpreted as, "the selective attitude adopted by a powerful empire in response to the developments outside its own sphere and area of influence". Ottomans started to transfer European technology, especially in the fields of firearms, cartography and mining as of the fifteenth century. Furthermore, the Ottomans obtained the opportunity to become acquainted with the Renaissance astronomy and medicine through Jewish scholars who took refuge in the Ottoman Empire. In spite of this, they considered themselves to be superior to the Europeans, both spiritually and culturally, in addition to their military power. Furthermore, their sufficiency from the aspect of both the educational system and economy was the reason for their being selective in the transfer of science. Thus, it is obvious that the Ottomans, in their periods of progress, did not feel the need to follow the intellectual and scientific activities such as the "Renaissance" and the "Scientific Revolution" emerging in the West. The interpretations of some of the modern historians in the direction that the Ottomans did not understand that such developments would constitute a danger for them in the future are anachronistic. Ottomans, along with the other societies which had their own civilizations, became aware of the unsurpassable advancement of the Europeans in science and technology with the effects of the Industrial Revolution. The military striking power of the Europeans that appeared as the result of the "Industrial Revolution" and which grew to an extent not comparable with the past, their speed in reaching every corner of the world on land and sea thanks to the steam engine; filling the world markets with goods unrivaled until then through new industrial production technology, established the crushing superiority of the Europeans.

The continuously expanding borders of the Ottomans during their first centuries, their seizing control of the Mediterranean, the naval campaigns in the Red Sea, Black Sea and the Indian Ocean caused them to have a need for new geographical knowledge. The works of classical Islamic geography and the contemporary literature in Europe became a source on this subject. Furthermore, Ottoman geographers also produced original works which included their own observations.

Ottoman cartography produced its greatest works with the activities of Piri

[12] For the critique from the aspect of the Ottoman world of theories claimed related to the spreading of the Western science outside of Europe by G. Bassala and L. Pyenson, see E. İhsanoğlu, "Ottomans and European Science," 37-48, T*he proceedings of the International Colloquium `Science and Empire`*, eds. P. Petitjean, C. Jami, and A.M. Moulin (Dortechht, Boston, London, 1992); for anather printing of the same article *Scientific Aspects of European Expansion*, ed. William K. Storey (Hamshire, 1996), 315-326.

Reis in the sixteenth century. The part of the map we have today that was drawn by Piri Reis in 1513 is a part of a large scale world map and it was presented to Selim I in Cairo in 1517. He based it on Christopher Columbus' map of America and different European and Islamic maps, as well as on his own experiences. This map includes information about the coastlines of Southwestern Europe, Northwestern Africa, Southeastern and Central America in the new world. This is a portolano type of map which does not have longitude and latitude lines, but incorporates the coasts and islands. Piri Reis presented his second map to Süleyman I in 1528. This map, of which only a small part has survived until the present, includes the North Atlantic Ocean and the newly explored places in Northern and Central America. Piri Reis wrote a geography book by the name of *Kitab-i Bahriye* which he presented to Süleyman I in 1525. This important book that he prepared by making use of Eastern and Western sources includes the maps and drawings of the cities in the Mediterranean and Aegean Seas and gives extensive information on navigation and marine astronomy based on his own observations.

Seydi Ali Reis (d. 1562), an admiral, is one of the outstanding persons on the subject of marine geography who wrote a very valuable work in Turkish called *el-Muhit* (The Ocean) containing astronomical and geographical information which is necessary for long sea voyages and his own observations on the Indian Ocean. On the other hand, Matrakçı Nasuh's work called *Beyan-ı Menazil-i Sefer-i Irakeyn* (Description of the Stopping Places on the Campaign to the Two Iraqs) written in Turkish is one of the best examples of descriptive geography.

The work titled *Tarih-i Hind-i Garbî* (History of the West Indies) (probably written by Muhammed b. Emir el-Suudî el-Niksarî [d. 1591] in the sixteenth century) is another study that mentions America and geographical discoveries. This work, based on sources written in Spanish and Italian, was presented to Sultan Murad III in 1573. It is composed of three sections, but the real weight, consisting of two-thirds of the book, is in the third section where exploits of Columbus, Magellan, Cortez and Pizarro over a period of sixty years and Columbus' discovery of America in 1492 to 1552 are related.

Katip Çelebi (d. 1657) translated the work of Mercator and A. S. Hondio called *Atlas Minor* with the name of *Levamiü'n- Nur fi Zulmeti Atlas Minor* (Flashes of Light on the Darkness of Atlas Minor) in the seventeenth century. His work titled *Cihannüma,* which he wrote by making use of the Western and Eastern sources, is a valuable work from the aspect of Ottoman geography and cultural history. Katip Çelebi enriched the Ottoman and Islamic culture and. was a great influence on the Ottoman scholars with his works in the field of bibliography and biography and his translations of some works of history by

European authors to Turkish, as well as *Cihannüma.* The Ottoman science of geography, which started in an earnest manner with Piri Reis, developed with *Cihannüma* and this movement continued without interruption until the nineteenth century.

The number of scientific works translated from European sources increased throughout the seventeenth century. It is observed that the gradual entry of the new scientific concepts into the Ottoman world of science started with these translations. The first work that was translated from European languages on the subject of astronomy is an astronomical table by French astronomer Noel Duret (d. ca. 1650) called *Nouvelle Théorie des Planetes* which was printed in Paris in 1635. Ottoman astronomer Tezkereci Köse İbrahim Efendi of Szigetvar translated this work in 1660 with the name of *Secenceli'l Eflak fî Gayeti't İdrak* (Miror of Revolving Spheres of Heaven on the Limits of Perception). This translation is at the same time the first book in Ottoman literature mentioning Copernicus and his heliocentric system of the universe. The first reaction to this book was given by Mehmed Efendi, the chief astronomer of the period, who said, "Such presumptuousness is abundant among the Europeans". However, after learning how to use it from the translator and after comparing it with the *Uluğ Bey Ziç* (The Astronomical Tables of Uluğ Bey), he appreciated the value of the work and awarded the translator. The initial reaction of the chief astronomer is a typical example of the cautious approach of the Ottomans who were sure of their own scientific tradition and acquisitions and did not immediately accept the scientific superiority of the West.

The matter of the sun being the center of the universe and the earth being in motions, which were the basic components of the perception of the new astronomy of Copernicus that created major disputes in Europe, were considered as a technical detail by the classical Ottoman astronomers and were not made a subject of polemics. Among the reasons is the fact that Ottoman astronomers did not know of any religious dogma which was opposed to it. The majority of the works on astronomy translated from European languages was composed of astronomical tables until the beginning of modern astronomy at the new educational institutions that were established in the last quarter of the eighteenth century and the beginning of the nineteenth century and acquired a sound identity.

The most important work on modern geography -besides Katip Çelebi's C*hannüma*- among those that were translated after the second half of the seventeenth century and in the eighteenth century is titled *Nusretü'l İslam ve's-Sürur fî Tahrir-i Atlas Mayor* (The Victory of Islam and Joy on the Redaction of Atlas Major) by Ebu Bekr b. Behram el-Dimaşkî (d. 1691). It is a nine volume work translated in a free style from the eleven volume work by Janszoon Blaeu in Latin which is known briefly as *Atlas Major.*

İbrahim Müteferrika (d. 1745), founder of the first Muslim printing house, attracted much interest with his edition of the *Cihannüma* printed in 1732 with the addition of appendices. Retranslated the work titled *Atlas Coalestis* (first printing 1708) by Andreas Cellarius upon the request of Sultan Ahmed III, under the name of *Mecmuatü'l Hey'eti'l Kadime ve'l Cedîde* (Collections of Ancient and Modern Astronomy) in 1733. Osman b. Abdülmenan, the Ottoman translator in Belgrade, translated Bernhard Varenius' work in Latin with the name of *Tercüme-i Kitab-ı Coğrafya* (Translation of the Book of Geography) in 1751. Besides these translations, the works on classical Ottoman astronomy and geography and the related scientific activities, preserved their continuity within the framework of their own classical tradition. When the Ottoman scientific literature of this period is examined as a whole, it can be said that after the Ottoman scholars overcame their feelings of superiority, they readily accepted the new knowledge, concepts and techniques. Neither the administrators nor the ulema displayed any negative attitudes as seen in the example of the heliocentric system of the universe. There were no conflicts between religion and the Western science at this stage. We observe another characteristic of the Ottoman scientific literature in the eighteenth century - some examples of this characteristic are also encountered at the beginning of the nineteenth century. This is the inclusion of the old Turkish-Islamic tradition of science along with the modern scientific knowledge of European source in the compiled or translated works. An example of this can be seen in the works where the geocentric and heliocentric models of the universe are presented together. Similar situations are also encountered in the field of medicine.

As of the sixteenth century, the arrival of some doctors from Europe in the major Ottoman cities, mainly in Istanbul, and at the same time the spread of many infectious diseases of European origin, brought with it new methods of medical treatment, prevention and ideas. The new medical doctrines of Paracelsus (d- 1541) and his followers, the theories and applications of treatment with chemicals which became widespread in Holland in the seventeenth century, the new iatrochemistry appeared in the Ottoman medical literature with the names of "tibb-i cedid" (modern medicine) and "ttbb-i kimyevi" (chemical medicine). Salih b. Masrullah b. Sellüm (d. 1670), who was one of the most famous followers of these developments, in his work called *Nuzhetü'l Ebdan* (Pleasure of Bodies) quotes many European sources and the compositions *of* their medicines. Furthermore, he translated Paracelsus' work on iatrochemistry from Latin into Arabic. In the same manner, el-İznikî (d. eighteenth century} also prepared his work called *Kitab-t Künüz-i Hayat el İnsan Kavanin-i Etibba-i Feylesofan* (The book on the treasury of the life of humans and the laws of the philosophers-physicians) in which he presented the old and new medicines together by making

use of the works of European doctors along with Arabic, Persian and Ancient Greek sources. Ömer Şifaî (d. 1742) stated that he translated his work called *el-Cevher el-Ferid* (Unique Jewel) from European languages into Turkish and that the compositions of medicines in the book were taken from the books of European doctors written in Latin. Thus, in the Ottoman medical literature, the new medical knowledge and methods of European origin and the medical knowledge and methods based on tradition were applied together until the beginning of the nineteenth century. [13]

Emergence of modern scientific literature in Turkish

The concepts and information related both to the East and the West appeared side by side in the Ottoman scientific literature in the eighteenth and early nineteenth centuries. An example is the presentation of the heliocentric and geocentric systems of the universe in the same work. It is possible to observe the same situation on the subject of medicine. In the eighteenth century, with the transfer of the practical medical knowledge of Europe, the classical concepts such as the "ahlat-i erbaa" (four humors) in physiology and traditional anatomy were still dominant.

The teachers at the Imperial School of Engineering that was established towards the end of the eighteenth century to teach modern sciences to the officers, prepared textbooks by translation and adaptation of the textbooks selected from among the scientific sources which were taught at the military technical schools in the West. The scientific publications at the beginning of the nineteenth century were the books prepared by Hüseyin Rıfkî Tamanî (d. 1817), Chief Instructor of the Imperial School of Engineering. They were compilations and translations on the subjects of astronomy, mathematics and geography and had many editions. These were followed by the works of İshak Efendi (d. 1836) who was Tamanî's student and successor as the chief instructor at the school of engineering. His works totaling thirteen volumes were also compilations and translations based on the Western and especially French sources. Among these *Mecmua-i Ulûm-i Riyaziye* (The Compendium of Mathematical Sciences), composed of four volumes, holds a special place because this work is the first wide scope attempt in the Ottoman world for the preparation of a textbook containing many branches of science. Mathematics, physics, chemistry,

[13] For early contacts with European sciences see E. İhsanoğlu, "Osmanlı Eğitim ve Bilim Müesseseleri", 271-278 (see note 1); E. İhsanoğlu, "Some remarks on Ottoman Science and its Relation with European Science & Technology up to the End of the Eighteenth Century", *Journal of the Japan Netherlands Institute,* 3 (Tokyo, 1991):45-73; and E. İhsanoğlu, "Tanzimat Öncesi ve Tanzimat Dönemi Osmanlı Bilim ve Eğitim Anlayışı" (The Ottoman perception of science and education in the pre-Tanzimat and Tanzimat periods), 335-395, in *150. Yılında Tanzimat* (The Tanzimat 150 years later), ed. Hakkı Dursun Yıldız, (Ankara, 1992).

astronomy, biology, botany and mineralogy can be enumerated among the subjects included; İshak Efendi had a significant role in finding the Turkish equivalents of the new scientific terms and their spread to the other provinces outside Istanbul.

Two individuals had a significant influence on Ottoman medical education around the beginning of the nineteenth century. The first is Şanizade Mehmed Ataullah Efendi (d. 1826), who was an encyclopedist having activities and interests in many fields and was familiar with the European science and various European languages. Şanizade in his famous work called *Hamse-i Şanizade*(Five Works of Şanizade) presented the knowledge of modern medicine and anatomy for the first time to the Ottoman readers in an understandable language and comprehensive manner. The second person is Mustafa Behcet Efendi (d. 1834) who was the founder of modern medical education.

The organization of education with a new perception after the proclamation of the Tanzimat, which was quite different as compared to the classical period, and the diffusion of modern education paved the way for the printing of a large number of books related to new sciences and technology. The number of scientific and technical books printed on various subjects rapidly increased towards the middle of the nineteenth century. While there were only 28 books printed on science from the establishment of the first printing house in 1727 up until the proclamation of the Tanzimat in 1839, this number reached 242 during the Tanzimat period (1839-1876). A comparison of the distribution of these books according to their subjects in these two periods shows that there were changes in the interest towards modern science. In the Tanzimat period, while there was a decrease of interest in military subjects, it is observed that the subjects related to civilian life and social matters became prominent. The same conclusions can be reached by an examination of the forewords of the books written on the same subjects around the beginning of the nineteenth century (both before and after the Tanzimat). While İshak Efendi in his work called *Mecmua-i Ulûm-i Riyaziye* mentions the importance of chemistry only for the war industry, Aziz Bey of Crimea in his work *Kimya-yi Tıbbî* (Medical Chemistry) (Istanbul, 1868-1871) states that chemistry forms the foundation of non-military technologies and many other industries.

It is observed that new and different subjects were also taken up among the scientific books printed after the Tanzimat. *Usul-i Kimya* (Fundamentals of Chemistry) (Istanbul, 1848) which is the first independent work published in Turkish on the subject of modern chemistry by Derviş Pasha and the book called *İlm-i Hayvanât ve Nebatât* (Zoology and Botany) (Istanbul, 1865) that was the first book on zoology and botany translated by Chief Physician Salih Efendi are such examples. Furthermore, while four scientific books were printed per year in the first thirty years after the proclamation of the Tanzimat, this number incre-

ased to eighteen per year in the six year period between "1870-1876". This is an indication of the increase of interest in the Ottoman society towards modern sciences.

The education was initially conducted in French at the Mekteb-i Tibbiye-i Şahane (Imperial Medical School), which was established in 1838 upon the model of European medical schools. In 1870 the decision was taken to conduct the education in Turkish. This also became a means for the development of medical literature in Turkish. As a result, especially after 1870, following the printing of *Lügat-i Tıbbiye,* the first Turkish medical dictionary (first edition in Istanbul in 1873, enlarged second edition in 1901), a great number of compilation and translation works on medicine and related subjects were published.

In the nineteenth century, Ottoman scientific literature studies aimed at research were started abroad, as the objective of research could not be completely realized at the institutions established within the country. The work in English called *Linear Algebra* compiled by Hüseyin Tevfik Pasha of Vidin is an example of an original study of the modern Ottoman scientists. [14]

The most noteworthy and important initiative from the aspect of the history of education in the nineteenth century is the opening of the "Darülfünûn" (University) besides the establishment of vocational and technical academies. The objective of research at the Darülfünûn-i Şahane (Imperial University), which could only be opened in 1900 after three unsuccessful attempts, was not realized on an extensive scale. However, it is too early to make a sound evaluation on this matter as the extent of the studies made on the Ottoman scientific literature until 1923 still have not been completely determined. It can be said that there was not much place for the objectives directed at research in the initial plans of the Darülfünûn, but this objective became more definite in time. The Ottoman Turkish was quite developed around the beginning of the twentieth century and acquired the status of a scientific language and the detailed terminologies that were developed became sufficient to express various sciences. As for the branches of science, there were sufficient textbooks and original publications to a lesser extent. [15]

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[14] E. İhsanoğlu, "Modernization Efforts in Science, Technology and Industry in the Ottoman Empire (18-l9th Centuries)", 15-35, in *The Introduction of Modern Science and Technology to Turkey and Japan: International Symposium October 7 11, 1996,* ed. Feza Günergun and Shigehisa Kuriyama, (Kyoto: International Research Center for Japanese Studies, 1998); for another printing of the same article see "Modernization Efforts in Science, Technology and Industry in the Ottoman Empire (18-190' Centuries)", 45-67, in *The Scientific Thought in the Modern Greek World 18th-19th Century* (Athens, 1998).

[15] For Darülfünûn see E. İhsanoğlu, "Dârülfünun Tarihçesine Giriş: İlk İki Teşebbüs" (An introduction to the brief history of the Dârülfünun: The first two attempts) *Belleten,* 54:210 (1990): 699-738; E. İhsanoğlu, "Dârülfünun" *DİA,* 8 (Istanbul, 1993): 521-525; E. İhsanoğlu, "Dârülfünun Tarihçesine Giriş (II). Üçüncü Teşebbüs Dârülfünun-ı Sultânî" (an introduction the brief history of the Dârülfünun (II) The third attempt Darülfünûn-ı Sultânî), *Belleten,* 57:218 (1993): 201-240; E. İhsanoğlu, "Dârülfünun", 559-562, in *Dünden Bugüne İstanbul Ansiklopedisi* (The Istanbul

New scientific institutions

In the nineteenth century, education in the "modern" sciences, such as medicine, chemistry, botany and zoology was extensive in the newly established educational institutions. Experiments were carried out in the laboratories established at these institutions. At the same time, new institutions were founded which enabled the application of these sciences in different fields. Among these, priority was given to institutions related to health services. The first applications on preventive medicine in the Ottoman Empire started with the quarantine organization in 1831, established especially for the Muslim pilgrims. Quarantine centers were opened in 1862 in many important cities in the vast lands of the Empire, such as Istanbul, Anatolia, Rumelia and the Arab Peninsula to combat infectious diseases. The Ottomans closely followed the latest developments in Europe on the subjects of public health and especially on the subjects of vaccination and microbiology. The lecture given by Pasteur in 1885 immediately after he found the rabies vaccine was published in a journal in Istanbul and a delegation of doctors was sent to Paris to learn the new developments on this subject. This delegation presented Pasteur with a jeweled Ottoman Medal of Honor and 10,000 French Francs sent by Sultan Abdulhamid II as an award for his studies. After the delegation's return, a "Da'ül-kelp Ameliyathanesi" (rabies laboratory) was established in cooperation with the local doctors and their colleagues who were invited from Europe. Later, a Bacteriological Laboratory was established for cholera epidemics. These institutions played a major role in the treatment of rabies, as well as vaccination and methods of treatment practiced during cholera and dysentery epidemics. In the same period, chemical analysis laboratories began to be established by the state for different purposes. Furthermore, it was observed that private chemical analysis laboratories were also established by individuals to meet the needs of the people.

Another modern scientific institution established in the nineteenth century was the "Rasathane-i Amire" (Imperial Observatory). The Imperial Observatory was established in 1863 and connected to the Ministry of Education under the administration of M. Coumbary, a French engineer. In spite of its name being an observatory, this institution performed the functions related to meteorology rather

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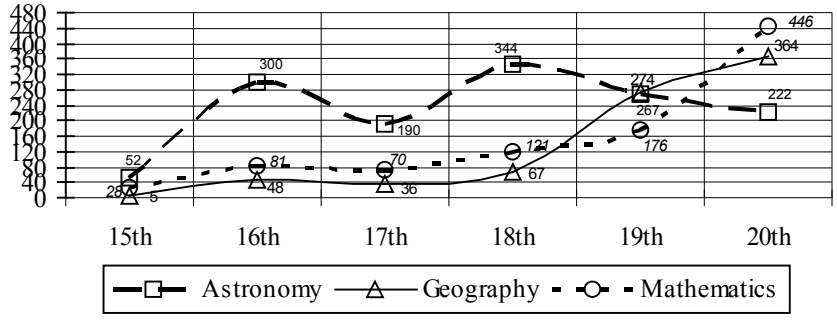
encyclopaedia from the past to the present), vol. 2, (Istanbul, 1994); E. İhsanoğlu, "Dârülfünûn: Mefhum ve Müessese Olarak Sultan II. Abdülhamid Dönemine Kadar Gelişmesi" (Dârülfünûn: The development up to the reign of Sultan Abdülhamid II as a concept and institution), 173-190, in *Sultan 11. Abdülhamid ve Devri Semineri* (Seminar on Sultan Abdülhamid II and his reign), 27-29 May 1992 (reprint) (Istanbul, 1994); E. İhsanoğlu, "The Genesis of Darülfünun': An Overview of Attempts to Establish the First Ottoman University", 827-842, in *Historie Economique et Sociale de l'Empire Ottoman et de la Turquie (1326-1960): Actes du Sixieme Congres International* Tenu à Aix-en Provence du 1er au 4 Juillet 1992, ed. Daniel Panzac, (Pans, 1995); and Ali Arslan, *Darülfünun'dan Üniversite'ye* (From the Darülfünun to the university), (Istanbul, 1995).

than astronomical observations. The Imperial Observatory prepared weather reports coming from the major cities and exchanged information with similar institutions in Europe. The succeeding Turkish administrators continued to perform the same services. Astronomer Fatin Gökmen (d. 1955), who had his secondary education at the madrasa and his higher education at the newly established Science Faculty of the University, was appointed as the last administrator and director of this institution in 1910. Besides preparing the weather reports at the Observatory, he made astronomical observations which were the real function of the institution. The Kandilli Observatory, located at the Kandilli district in Istanbul, connected to the Boğaziçi University, continues to be an important observation center in Turkey today.[16]

A general evolution of the scientific language and literature

In recent years, as a result of the increasing research and studies on the survey and cataloging of Ottoman scientific literature, our knowledge of Ottoman literature on astronomy, mathematics and geography has been enriched to a great extent and many new aspects of scientific activities of the Ottoman period were revealed. The results of these studies also illustrate with complete clarity the intensity of scientific activities carried out by the Ottomans. The examination of this literature shows that a total of 582 authors produced 2438 works on astronomy; 491 authors that we were able to establish produced 1,116 works on mathematics and 458 authors produced 825 works on geography. The distribution of these works by centuries is as follows: The works, the dates of which could not be established, are not included in the graph.

Distribution of Works According to Centuries



[16] E. İhsanoğlu, "Osmanlı Eğitim ve Bilim Müesseseleri", 353-354. See note 1.

According to this statistical information, the total number of astronomical works is more than the number of mathematical works. This situation stems from the fact that calendars specifically occupied an imported place in astronomy literature. A continuous increase is observed in the number of works in these three disciplines until the eighteenth century. The number of works attained their maximum in the eighteenth century and then started to decrease. As for mathematics, the total number of works continued to increase except for the eighteenth century. Works on mathematics, which recorded a major increase especially in the nineteenth century, attained the maximum in the twentieth century. There is also an increase in the total number of works on geography similar to that of mathematics. The rates of increase of the works in these three subjects are close to each other.

As of the fourteenth and fifteenth centuries, Ottoman scientific literature, which was initially written in Arabic, was frequently written in Turkish with the start of translations from Arabic and Persian. This situation also enriched Turkish scientific literature and constituted terminologies in various branches.

The language of Ottoman scientific literature was Turkish and Arabic in the eighteenth and nineteenth centuries. Persian works were very few (1 percent). Ratios of all of the works (handwritten or printed) written in Turkish and Arabic also show differences. Works prepared on modern science and technology that were printed in Istanbul during these two centuries - other than a few exceptions - were completely in Turkish, whereas the majority of handwritten works were in Arabic. Out of the 344 handwritten and printed books on astronomy in the eighteenth century, the language of 331 works were determined; 221 were in Arabic, 101 in Turkish, 2 in Persian and 7 in a combination of these three languages. Similarly, out of the total of 267 works *on* astronomy in the nineteenth century, the language of 263 works were determined and 137 were in Arabic, 123 in Turkish, and 3 were in mixed languages. These numbers clearly indicate that the use of Turkish had increased while the total number of works decreased. This shows that in the nineteenth century, the use of printed works because of the prevalence of modern schools and educational institutions had accelerated the transition from the Eastern handwritten tradition to the modern printing tradition.

A great majority *of* the books written on modern astronomy within the borders of the Ottoman Empire, excluding the Arab lands, were written in Turkish. It is possible to record the same observations for Ottoman mathematics literature. In conclusion it can be said that handwritten works prepared in the eighteenth and nineteenth centuries were in Arabic or Turkish, but printed works (with the exception of Arab Provinces) were almost entirely in Turkish. [17]

[17] For extensive information and evaluation also see E. İhsanoğlu, Ramazan Şeşen et al., *Osmanlı Astronomi Literatürü Tarihi* (The history of the Ottoman astronomy literature), 2 vols.,

Conclusion

As it is seen above, during the classical period, Ottoman scientific activities were conducted mainly in the madrasas, Şifahanes and muvakkithanes where the sciences of medicine, mathematics and astronomy were practiced together with the teaching of these sciences. Towards the end of the sixteenth century, Takiyeddin el-Rasıd founded the Istanbul Observatory. Original studies that were in a way the continuation of the Islamic tradition of astronomy were carried out and new instruments of astronomy were used together with the old. The results of these studies were collected in books. The formation of the classical period Ottoman literature was generally realized in the madrasa environment and in the fields of religious subjects, mathematics, medicine and astronomy. A great number of scientific works in Arabic, Turkish and a few in Persian were produced by the scholars through research, study, compilation, translation or interpretation.

One of the important conclusions set forth here is the contribution made to the formation of the Ottoman scientific literature by the scholars from Anatolia who were educated in the cultural centers within the Ottoman territories and the scholars who were educated outside these centers and then came under the patronage of the Ottomans. The support extended by the sultans and other statesmen ranging from the establishment of madrasas, their encouragement of translations, compilations and the writing of different books had an important role in the formation of the classical period Ottoman scientific tradition.

Ottomans, who were aware of the scientific and technological developments in Europe, became interested in the Western science and technology, especially as of the end of the seventeenth century, and abandoned the limited, selective transfer of information which had been applied ever since the early days of the Empire, so that they could learn the new techniques of war. They closely followed the innovations in Europe, as of around the beginning of the eighteenth century, and started to take steps to make significant changes within the army with the assistance of European experts. New institutions were established in the framework of the activities that were concentrated especially on the subject of modern military technical training. These activities, with the establishment of the Ulufeli Humbaracı Ocağı (Corps of Bombardiers), continued in the nineteenth century with the opening of the schools of engineering and other military schools. As explained extensively in the chapter related to education, modern civilian educational institutions providing primary,

(Istanbul, 1997); E. İhsanoğlu, Ramazan Şeşen and Cevat İzgi, *Osmanlı Matematik Literatürü Tarihi* (The history of Ottoman mathematics literature), 2 vols., (Istanbul, 1999); and E. İhsanoğlu, *Açıklamalı Türk Kimya Eserleri Bibliyografyası* (Anotated Bibliography of Turkish chemistry works), (Istanbul, 1985).

secondary and higher education were established together with the institutions providing military and technical education. Daily newspapers and periodicals gave information on the subject of modern science and technology. Taking all of the above into consideration, it was possible to introduce modern science and technology to the masses at various levels. [18]

Ottoman intellectuals also established civil learned societies and professional associations besides the official educational institutions and expended great efforts to constitute modern scientific literature in Turkish and to publish dictionaries of modern scientific and scholarly terminology. [19]

It seems that the Ottoman's perception of modern European scientific tradition lacked an overall approach though they followed it closely. It is also clear that their scientific activities concerning research and production of new knowledge and technology – despite various relevant examples- did not have priority in their planning. The research activities conducted by Ottoman scientists inside and outside the Empire, particularly in the European countries did not reach the critical mass as compared to the contemporary Russian or Japanese examples.

During the classical period, the Ottoman scientists and scholars showed a remarkable success in developing science and were able to make new contributions to various branches of science. However, in the modernization period, they were not able to show a parallel performance, but were successful in developing modern scientific terminology of universal Islamic character and the Ottoman Turkish language to a level that would enable them to express modern scientific and scholarly knowledge on various disciplines. The cultural and scientific heritage of the Ottoman period constituted the scientific and cultural infrastructure of many states founded in the Balkans and the Middle East, with the Republic of Turkey in the lead, and formed the foundation of the subsequent activities.

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[18] Orhan Koloğlu, *Halka Doğru Bilim*, TBTK (Turkish Society for History of Science) (İstanbul, 1997).

[19] For extensive information on the subject of the learned societies see *Osmanlı ilmi ve Meslekî Cemiyetleri* (Ottoman learned and professional associations), ed. E. İhsanoğlu (Istanbul, 1987); Ekmeleddin İhsanoğlu, "Osmanlı Türkiyesinde Kültür ve Bilim Hayatında Tüzel Kişiliğin Gelişmesi ve Teşkilatlanmanın Başlaması" (The development of juristic personalities in the cultural and scientific life in Ottoman Turkey and the start of organization), *Erdem*; Aydın Sayılı Özel Sayısı 19 (25), (May 1996), 265-292; E. İhsanoğlu, "Genesis of Learned Societies and Professional Associations in Ottoman Turkey", *Archivum Ottomanicum*, 14 (1995-1996), 161-189.