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Turkish Contributions to Scientific Work in Islam

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TURKISH CONTRIBUTIONS TO SCIENTIFIC WORK IN ISLAM

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Mesopotamia and Egypt were the cradles of our present-day civilization. The origins of today science can be traced back to these two civilizations of four or even five thousand years ago. The Greeks inherited the science of these countries appropriated it eagerly. They also endowed it with greater power of articulation and imparted fresh momentum to scientific work. In their hands scientific knowledge was not only considerably enriched, but it also gained substantially in refinement and theoretical stature. But with the beginning of Christianity a period of stagnation gradually set in, and the era called the **Dark Ages** with all its superstitions and dearth of well-founded scientific enlightenment began to weigh heavily upon the old classical Mediterranean world and the Near East. The situation changed with the advent of Islam.

The history of Islam starts with the Hijra in 622 CE. In that year our Prophet Muhammed transferred the scene of his activities from the city of Mecca to Medina. The Prophet died ten years later, but before 650 CE the Muslims had managed to conquer Syria, Egypt, Mesopotamia, and Persia, and in these rapid conquests religious faith had served remarkably as a motive power for building a gigantic empire.

In the Near and the Middle East the Arab conquerors met with remnants of civilizations much superior to their own, and, as the Islamic community became welded together, these civilizations cooperated actively in the formation of the emerging Muslim civilization. In the vast territory embraced by Islam the Arabs were considerably outnumbered by the non-Arabic elements and, consequently their control over the destiny of Islam decreased significantly. The original conquerors played by no means a passive part, however, in the emergence of the new society.

> *The rise of the Abbasid Caliphate, about one hundred and twenty years after the death of the Prophet, marked the opening of a cultural and scientific era, important not only in the history of Islam but also in that of the whole world. This was made possible by the great value attached to knowledge and culture. Consequently, an intense process of cultivation of knowledge constituted a veritably strong component in the very foundations of the emerging Islamic civilization.*

Moreover, this enthusiasm was far from being limited to religious and literary fields. The existence of rich Indian and especially Greek scientific and medical literature was gradually discovered, and an aggressive curiosity to gain access to and appropriate that knowledge resulted. A great stream of Greek and other ancient learning began to pour into the Muslim World through the then newly founded city of Baghdad as a result of systematic and intense translation activities. Translations were made into Arabic from Greek, Sanskrit, Syriac and from the Pahlawi language.

At the court of the second Abbasid caliph Al-Mansur we witness acts of courtesy extended to scholars from India or from regions close to India who brought with them important Sanskrit works on astronomy, trigonometry, and medicine. And the same caliph received an important collection of manuscripts including

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Euclid's *Elements of Geometry.* Through the initiative of Harun al-Rashid and also the Barmaks, originating from a family of high rank in the Buddhistic religious hierarchy of the city of Balkh, many additional scientific manuscripts of great importance were secured and the Baytulhikma was founded where these works were busily translated into Arabic. The seventh Abbasid caliph and son of Harun al-Rashid, Al-Ma'mun (813-833), took considerable pains to obtain Greek manuscripts and sent a special mission to the Byzantine emperor for that purpose.
Resolved to pursue knowledge to its sources, Hunayn ibn Ishaq famous physician and translator of Christian faith, decided to discontinue his medical studies until he had perfected his knowledge of the Greek language and for that purpose went into seclusion for many years.

One feature of the medieval Islamic culture, which seems to be very significant for the intellectual history of the world, is the conspicuous achievements in the organization and systematisation of education that were realized in Islam. Great strides were made in the direction of the dissemination and popularisation of learning, especially in the field of Islamic or transmitted sciences.

In the Islamic Middle Ages, for the first time in history, the cultivation of knowledge came to be looked upon as something that has to be within the reach of every individual. The abundance of public libraries and of schools, even those devoted to higher education, is a shining witness of this attitude and of the extent to which a goal so difficult to be attained was realized in practice. In addition, in Islam the promotion of education came to be considered a duty of the state.

There were several sayings attributed to the Prophet advocating the cultivation of knowledge and exalting the scholars. There is, it is true, the question of the authenticity of these Traditions. But some of these sayings at least should be genuine , since they are found in the earliest and most reliable collections of the sayings of the Prophet. Moreover, there are many verses in the Koran in which seeking knowledge is highly recommended. The sayings in question of the Prophet are therefore in complete harmony with these Koranic exhortations. Certain medieval Islamic thinkers tended to interpret the word "**knowledge**" in such passages so as to exclude the mathematical, physical, and natural sciences. Many scientists, however, referred to such verses and Traditions in exalting their fields of endeavour. These verses and Traditions undoubtedly acted therefore as strong stimulants in the cultivation of the secular sciences as well as in the popularisation of education in general.

An economical way of manufacturing a suitable from of rag paper was found and perfected in China. Muslims learned the manufacture of paper from Turkistan, and this industry was soon adopted all over the Muslim realm. This economic factor too should be considered of great consequence. The manufacture of paper has probably played as important a part in the promotion of education and dissemination of knowledge as the invention of the printing press with movable types did some centuries later in Europe. It must have been of service also in securing and facilitating contact between Europe and the Islamic World. We know that this contact proved to be of great importance in the intellectual history of the world.

Certain Islamic scholars, such as **Al-Bîrûnî** and **Rashiduddin**, physician, historian, and statesman, have criticized the Arabic script. They dwell upon certain disadvantages of that script, and their criticisms are very relevant from the point of view of the production of men of science and learning. Their thoughts have the earmarks of a deep interest in the question of the dissemination of knowledge.

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The achievements of Islam in the direction of the popularisation of education should be included among its major contributions to world civilization. The question of the relation between the Islamic madrasa and the late medieval European university seems to gain considerably in importance when considered against the background of the Islamic contributions to the democratisation of education.

The organization of education in Islam reveals some rather important contributions of the Turks to Islamic civilization. The madrasa system came into being during the period of Turkish rule, the first of such institutions formally supported by the state being a creation of the Turkish Seljuqs. In a more general sense too the birth of the madrasa system owed much to Turkish initiative. It was developed in the region of Transoxiana and Khorasan, where Turks constituted a significant part of the population, and Turkish kings of the Qarakhanid, Ghaznawid, and Seljuq dynasties were the founders of the earliest of such schools. Turks appear, moreover, among the earliest bibliophiles and founders of libraries in Islam.

Persia was almost completely conquered by Muslim armies in the time of the caliph Omar, in 641, only nine years after the death of the Prophet, and about ten years later the Sasanid monarch fell in the hand of the Arab armies in Merv. From this point on, from the Caspian to the south of Afghanistan, the Arab armies met, in their advance, with local Turkish resistance, and the conquest of Transoxiana and Tokharistan with its capital Balkh could be brought to a successful conclusion only through the energetic initiatives of Qutayba ibn Muslim about a hundred years after the death of the Prophet.

Turks thus came to constitute a part of the Muslim community, and from this time on they undertook to defend the borders of Islam, while the other Turks of Central Asia from outside the Islamic realm began to accept the Muslim faith. Al-Ma'mun had a sizeable body of Turkish soldiers in Baghdad, who according to Jahiz, were the most capable and efficient of his military personnel, while with his successor Al-Mu’tasim (833-842) opened a period of predominance of Turkish army officers of high rank. This gave rise to the so-called Samarra period, during which the seat of government was moved from Baghdad to Samarra. This period lasted from 836 to 892, extending through the reigns of eight successive caliphs.

Already in the ninth century independent Turkish states began to spring up in Islam, not only such as the Qarakhanids and the Ghaznawids in Central Asia, but such as the Tulunids and the Ikhshidids in Egypt, in the heart of the vast Islamic realm. But Turks were not active and efficient only in administrative and military affairs and in the field of statesmanship. For the cities of Central Asia soon gained pre-eminence not only as nurseries of Islamic studies but also as cultural centres where valuable scientific work was carried on extensively.
W. Barthold observesation the importance of cooperation between peoples of different geographic regions in building up the Islamic civilization. He sees the main significance of the rise of Islam, for the intellectual history of the world, in the circumstance that thereby a realm came into being in which the cultural cooperation of a considerable part of mankind was possible.

The vast Islamic territory extending from the Pyrenees and the Atlantic Ocean, through North Africa, to Central Asia and the Indian Ocean embraced many groups of people of different ethnic origins. Religion was the main common bond, but there were also different faiths and many denominational variations. And although sectarian ideologies were often utilized in the foundation of regional kingdoms, as the Muslim religion itself had served as the motive power of building an empire, yet a state of tolerance prevailed in Islam that was quite remarkable. Moreover, belief in the paramount importance of the Arabic language, the

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language of the Koran and the Prophet, was, more or less, an article of faith among the Muslims, and thus Arabic also served as a veritable common bond in the huge Muslim domain.
It is of interest to consider the following assertion of Al-Bîrûnî, a truly towering genius of medieval Islam, in the light of this general perspective. He says, "The ideas and convictions of people often show great diversities, and the prosperity of the world rests on such divergences of opinion."

In Zeki Velidi Togan's estimation and interpretation, Al-Bîrûnî conceived the world civilization as divided into two major groups. These were the **Orient** and the **Occident**. The former comprised the Indians, the Chinese, and the Turks remaining outside the sphere of the Islamic culture. Islam itself constituted a continuation of the **Classical World of Antiquity**. Al-Bîrûnî is thus seen to attach great importance to the elements of continuity tying the ancient Greek civilization to Islam and made possible especially through the activity of translation. Moreover, Al-Bîrûnî believed that the acceptance of the Muslim faith by the Turks resulted in a great extension of the sphere of the Occidental civilization and that thereby an important service was rendered to humanity.

> *Such high thoughts of Al-Bîrûnî are significant proof of Barthold's statement referred to above. The Persians played a great part in the intellectual and scientific activity of Islam. Moreover, a galaxy of truly remarkable thinkers and scientists of Islam are seen to have originated from the northeastern regions of Islam, from the districts of Khurasan and Central Asia in general. AI-Farabi, Al-Bîrûnî, Ibn Sina, Nasiruddin at-Tusi, and Ulugh Bey constitute examples of the vast group of scientists and thinkers from the districts of Khurasan and Transoxiana.*

Such people were partly Persian and partly Turkish and did not feel the need to specify their ethnic origins. Only in certain exceptional cases, therefore, are we able to clearly distinguish their nationalities either on the basis of casual information concerning their lives which has come down to us, or because such inference becomes clearly possible from the titles they bore, or, in the case of scholars and scientists who lived in the earlier centuries especially, from the names of their ancestors.

For example, such scholars as Abu Nasr Muhammad ibn Muhammad ibn Tarkhan ibn Uzlugh al-Farabi (d. 950-951), the dean of the philosophers and logicians of Islam and one of its most distinguished scientists, musicologists, and thinkers, and Abu Nasr Ismail al-Jawhari al-Farabi (d. 1002), one of its first lexicographers, bore the title «al-Turki", i.e., "the Turk" or "the Turkish". They both originated from Farab, a city deep in the lands inhabited by Turks, as their title al-Farabi indicates. Likewise, certain other scholars were referred to by the title "al-Farsi", i.e., "the Persian", or "from Fars". Concerning Abu Nasr Muhammad al-Farabi, to whom several sources specifically refer as Turkish, we know, in addition, that throughout his long span of life he never abandoned the habit of wearing Turkish costumes and Turkish hat. Moreover, the names of his forefathers, Tarkhan and Uzlugh, are Turkish.

With the advent of the Seljuqs Turks migrating in such large numbers into Islamic territories, that the part of this population which settled in Asia Minor was able to transform that territory into a predominantly Turkish country in a relatively short time. From the eleventh century on, therefore, Turks could be expected to be encountered in any part of the Islamic East. But before the Seljuqs geographic considerations could serve more reliably as guides for the likelihood of Turkish and Persian origins.

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Abu Bakr Muhammed ibn Zekeriya ar-Razi, great physician and chemist and one of the foremost representatives of free and independent thought in Islam, who originated from Ray, on the outskirts of present-day Tehran, may, solely on the basis of geographic criterion, be considered a Persian. Abu'l-'Abbas Ahmed al-Farghani, who was a contemporary of Al-Ma'mun and Al-Mutawakkil, on the other hand, may for similar reasons be deemed to be a Turk, while for scholars from Khurasan and its close neighbourhoods it would be more difficult to reach such verdicts.
There is no need to emphasize that such a criterion alone would not be conclusive in individual cases, but could merely serve to establish a probability. As the examples are multiplied, however, the probability of making mistakes on the basis of geographical criteria alone should undoubtedly decrease. In dealing with individual cases therefore it is very desirable to rely upon more specific and detailed items of information.

Al-Bîrûnî, for example, tells us that his mother tongue was neither Arabic nor Persian. He adds, moreover, that it is impossible to write scientific books in his maternal language. He asserts that Arabic is the language appropriate for writing books of science and learning and that Persian is suitable for eulogies and evening stories, adding, however, that he himself would prefer criticism in Arabic to being praised in Persian.

Al-Bîrûnî is seen to have known Turkish from occasional references he makes to words in that language. Apparently he knew Turkish already in his very tender ages. For at least on two occasions he speaks of somewhat detailed childhood memories concerning aged Turks who brought medicines made of herbs to his native town, one of them being to the palace of Khwarazm. Moreover, Al-Bîrûnî's Turkish was, according to Zeki Velidi Togan, that of the Turks of his native country. And it is very unlikely that Al-Bîrûnî's acquaintance with Turkish was a result of his formal or private education.

We may conclude that **Al-Bîrûnî** was most certainly not Persian and was very likely **Turkish**. His case is somewhat like that of A1-Farabi, in that there exist certain detailed items of information that make possible the determination of his nationality.

It is of course not in any way essential or necessary to determine the nationalities of these scientists and thinkers one by one. But it is certainly of importance to do some such work at least in order to show that the production of such men was not a monopoly of any single national or racial group.

In the medieval Islamic World the patronage and encouragement of scientists and their work by kings and people of high rank such as viziers was an important factor in the production of scientists and the continuation of scientific work. For in Islam the principle of utility was of considerable weight in deciding in favour or against a branch of knowledge, and the Muslims were quite conscious of this pragmatic test and often mentioned it as a legitimate criterion. Notwithstanding certain apt criticisms directed against astrology and alchemy, on the other hand, the feeling of dependability on these pseudo-sciences was quite strong and widespread in Islam, and the encouragement and patronage accorded to them was quite substantial. Quite naturally, medicine also enjoyed popular and royal support.

In Islam astrology, with its branches, thrived well in royal courts. Moreover, in many cases, kings and princes patronized the type of astrology that required elaborate mathematical treatment and accurate observations with costly instruments.

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Without this kind of royal patronage the popularity of astrology might have not served to encourage the cultivation of mathematics and pure astronomy to any considerable extent beyond that part falling within the province of the *muwaqqit (a time-keeper employed by a mosque)* and satisfying the needs of religion.

Indeed, in it became the case that in the Muslim world the transmitted sciences, i.e., those related to Islamic studies, were considered to be of far greater value as compared to the secular sciences, while the latter were subject to mild scepticism and suspicion and, at times, were made targets of rather severe criticism and of even active opposition. It may be said without hesitation that the support afforded by the kings to astrology, alchemy, and, at least thereby, to the secular sciences was quite often rather substantial. Indeed, royal patronage generally extended to the basic secular sciences quite generously.

Royal patronage of the secular sciences was undoubtedly an important factor in counteracting lay and theological disapprovals of the secular sciences. For kings usually combined temporal authority with some degree of spiritual power, and their authority was generally absolute both in theory and practice. It was also a favourable circumstance from the vantage point of the cultivation of such knowledge that in Islam the system of a plurality of relatively small states rather than that of large central governments generally tended to prevail.

Indeed, beginning with the Abbasid caliphs such as Al-Mansur, Harun Rashid, Al-Ma'mun, Al-Mu'tasim, and Al-Mutawakkil, royal patronage was the prime-moving factor in the intellectual development that lay at the foundation of the emerging Islamic civilization. Turks, on the other hand, assumed an active part in administrative, military, and political affairs from relatively early years of the Abbasid rule on, as we have already seen, and soon they extended this activity of statesmanship by founding or heading many Islamic states. They were thereby instrumental to quite a substantial extent in promoting scientific work.

The most illustrious among Turkish rulers who encouraged and promoted scientific work is, without any doubt, Ulugh Bey. Indeed, if only three rulers should be singled out for consideration as the most remarkable patrons of science throughout the Middle Ages, they would undoubtedly be Al-Ma'mun, Alfonso X, and Ulugh Bey, and Ulugh Bey should certainly be ranked as the most enlightened among them. There will be occasion in the following pages to refer to other Turkish rulers who patronized scientific work when speaking of observatories and hospitals. Names of Turkish rulers in Islam who encouraged scientific work and were personally interested in its cultivation would run into a quite long list. It will be of interest, however, to mention here two specific examples of Turkish rulers who are most certainly not among the top celebrities and are in fact quite obscure.

Mughith al-Din Muhammed ibn Arslanshah of the twelfth century, the seventh king of Seljuqs of Kirman, was very fond of astronomy and astrology. He possessed some knowledge in these fields and in the science of calendar. He gave unusual encouragement to the pursuit of learning and supported promising young students by giving them pecuniary rewards. And according to Ibn Bibi, (Alauddin Dawudshah ibn Bahramshah, thirteenth century ruler of Erzincan was very learned in the science of stars, including astrology, and in mathematics, medicine, natural sciences, and logic, and could write good poetry. In the Near and Middle East the Arab conquerors, as mentioned above, had come into contact with civilizations or remnants of civilizations far superior to their own, and as the Islamic community became welded together, these civilizations were duly represented in the emerging Muslim society. But in consolidating the intellectual foundations of the new society much concerted effort was expended and contact was secured

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also with cultures not so readily accessible. This was done, as said above, through systematic translation activities.

Learned people made from Syria, Iraq, and Persia, people mostly belonging to the Nestorian and Monophysite sects made the majority of these translations. But there were also prominent Muslim Arabs as well as Jews and Zoroastrians among the translators. Harran, a pagan centre representing predominantly the ancient Mesopotamian civilization, Jundisapur, a predominantly Nestorian medical centre in southwestern Persia, and Merv, at the edge of the district of Khurasan, and well within the borderlands of Central Asia, where the Nestorians had set up a centre, were foremost among such cultural centres.

This brings us back to the regions to the northeast of Iran, and we may say that in the matter of the first fruitful intellectual contacts, certain early scholars of this area were among the trailblazers in translations from Sanskrit. Likewise, the Jewish scholar Sahl ibn Rabban at-Tabari from Merv figures among the earliest translators of the *Almagest* of Ptolemy.

Figure 1. A horse anatomy figure drawn by Muslim surgeon.

Indeed, AI-Farabi clearly states that the last representatives of the tradition of instruction of philosophy in Alexandria and Antioch moved to Merv when the representatives of this tradition had to quit those cities and that they continued their activity in that new centre. It should be of interest in this connection too that a man from Balkh and one from Nishabur, both in the regions in the north-east of Persia, are mentioned as teachers of Abu Bakr Muhammed ibn Zakariyya ar-Razi, a truly towering thinker and scientist of early Islam whose life stretches from 864: to 925 C.E.

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The illustrious pre-Islamic medical centre, Jundisapur, owed its importance particularly to Nestorian physicians who were forced to leave the territories of the Eastern Roman Empire because of their religious views and had enjoyed the protection of Iran. In Jundisapur there was a hospital which was apparently the most advanced institution of its kind in that era and which, most likely, served as the leading model for the medieval hospitals of Islam.

It would seem that this medieval centre had been influenced to some extent by Indian medicine, but the predominant influence had come from the healing art of the Greeks, and Jundisapur was at the time the foremost representative of Greek medicine. The physicians of Jundisapur were among the promoters of the translation activity from Greek and Syriac into Arabic, in which some of them also participated personally.

The hospitals of medieval Islam are in the true sense of the word the forerunners of the modern hospital. The Greek asklepion was a temple of cure dedicated to the gods of healing. These institutions were shrines of miraculous cure with mystifying atmospheres calculated to have psychological effects on the patients, and in them, ordinarily, physicians practising Greek scientific medicine played no part. The Islamic hospitals, on the contrary, were well-organized and specialized institutions of charity, and they constituted strongholds of scientific medicine.

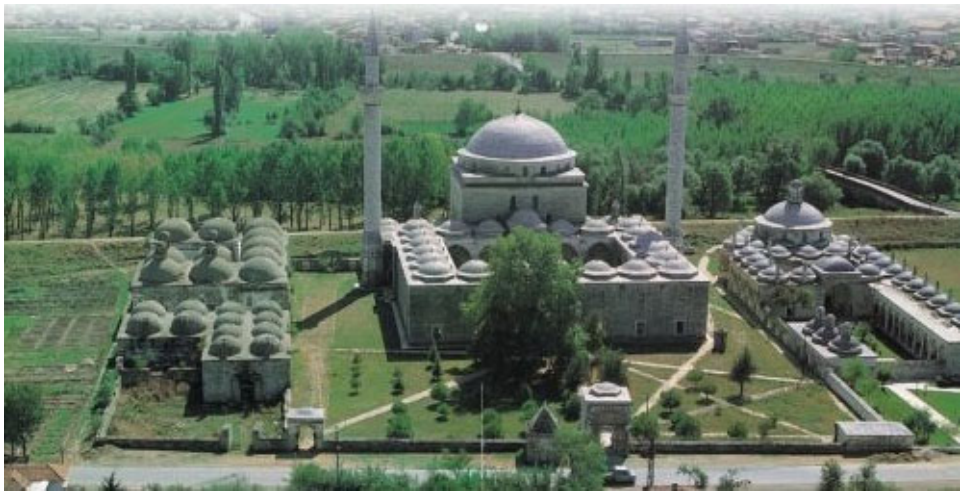

Figure 2. Sultan Bayazid II Mental Hospital and Medical Madrasa in Edirne, Turkey.

It is of great interest therefore that in the development of the hospital as a specialized philanthropic and scientific institution Turks seem to have played a prominent part. The fifth Islamic hospital was built by Fath ibn Khaqan ibn Gartuch, Turkish general and minister of the Abbasid caliph Al-Mutawakkil, and the sixth one by Ahmed ibn Tulun. This latter institution was the first Islamic hospital supported by the *waqf* endowment. It may be added that out of the five earliest hospitals that had *waqf,* the Turks built three or possibly four of them.

> *The third Islamic hospital owed its existence to the initiative of the Barmaks who were from Balkh, and they may have had a hand in the foundation of the first Islamic hospital too. Representatives of Indian medicine ran the third Islamic hospital, and some such a situation may have obtained to some extent in the first Islamic hospital too. It should be added here that hospital-building activity*

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gained great momentum beginning with the Seljuqs, i.e., during the period of prevalence of Turkish political power in Islam.

Like the hospital the observatory too was one of the most developed institutions of science and learning in Islam and one of the high-water marks of the Muslim civilization. There is no doubt that the observatory, as a specialized scientific institution owes a great deal to Islam. It may very reasonably be claimed, in fact, that it was first in Islam that the observatory, as a specialized institution with an official and legal status and with a fixed location where observation and other work on stellar bodies was carried out systematically through the cooperation of several scientists, came *into* existence. Al-Ma'mun set the example and initiated the tradition of founding observatories *in* Islam, and that monarch founded two of the major but very short-lived observatories, the Shammaslya in Baghdad and Qasiyun in Damascus.

Figure 3. Taqi al-Din and his colleagues in Istanbul Observatory miniature.

Eight other examples of enterprises for building full-fledged and elaborate official state observatories occurred in the Islamic realm up to the seventeenth century. The earliest in date among them was the Sharaf ad-Dawla Observatory built in 987 in Baghdad. This was an elaborate institution, but it was quite short-lived, apparently because it suffered from the ambitiousness of its project. The Turkish king Melikshah in Isfahan founded the next large-scale observatory in 1074. Al-Afdal and Al-Bata'ihi, two Fatimid viziers, were active in the building of an observatory in Cairo between 1120 and 1125. But the project could not be brought to full completion.

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The Maragha Observatory, founded in 1259 under the patronage of Hulagu was one of the most elaborate institutions of its kind and the scene of important work. About 1300, Ghazan Khan founded another observatory in Tebriz, the characteristic feature of which seems to have been the weight given in it to instruction in astronomy. A gigantic observatory was built in Samarqand by the Turkish astronomer prince Ulugh Bey in 1420, and finally the Tophane Observatory of Istanbul was founded by the Ottoman ruler Murad III in 1575 or shortly thereafter.

It is seen that three out of these ten institutions owed their existence to Turkish rulers, and two among the remaining seven also belong to the period of Mongol-Turkish rule. Out of these five observatories, moreover, four were the most elaborate and the most highly developed of such institutions ever built in the World of Islam, while the fifth one, that founded by Ghazan Khan, is of great interest because of its special feature connected with the dissemination of the knowledge of astronomy and the mathematical sciences, and also because it seems to bring into relief the effort to more truly integrate the observatory with the characteristics of the Islamic society through the endowment of that institution with *waqf* revenues.

It may be added that Ulugh Bey was about twenty-five years old when he founded his observatory. The Turkish scientist Salahuddin Qadizade-i Rumi from far away Bursa in Anatolia played a great part in the formation of the scientific circle of Samarqand headed and patronized by Ulugh Bey. Qadizade had travelled to Samarqand to enrich his scientific knowledge. In his efforts to procure his travel expenses his sister, who sold her jewelery for that purpose, supported him. He became there a student of Sayyid Sharif-i Juzjani.

It is very likely that in his decision to set up an observatory, Ulugh Bey was inspired at least partly by Qadizade. He was the teacher of Ulugh Bey who made him the director of his Samarqand Madrasa. In the introduction to his *Zij* Ulugh Bey writes: "...The work was started jointly, with the aid and assistance of His Excellency my master and my support, the most learned of the men of learning, the bearer of the banner of virtue and sagacity, the devotee of the path of truth and the guide of the road of scrutiny, our *mawlâ* Salah al-Molla wa'd-Din Musa, famous as Qadizade-i Rumi, may God's mercy and compassion be upon him. ..."

In Islam there were rather important special observatories set up by individual astronomers and also observation posts with limited scope of work, some of which were quite elaborate though necessarily of a temporary nature and generally of short periods of activity. Real institutions should transcend individuals, and therefore special observatories belonging to individual astronomers are relatively in the background from the standpoint of the development of the observatory as an organized and specialized scientific institution. Nevertheless, such special observatories played an at least indirect part of primary significance in the birth and growth of that institution.

One such special observatory of great interest and of quite early date was that belonging to the Turkish Amajur family. Abu'l-Qasim Abdullah ibn Amajur, his son Abu'l Hasan 'Ali, a third member of the family, and Ali's freed slave Muflih ibn Yusuf were among the greatest recorder of astronomical observations of Islam. There is a record concerning a certain Amajur who was a high official of Damasscus and who died about 878. He may have belonged to the same family.

The Amajurs made extensive astronomical observations between 885 and 933, and, at times, seem to have had other collaborators. Their observations were made partly in Shiraz and mostly in Baghdad, and their

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work included observations of the fixed stars, as well as lunar, solar, and planetary observations. The Amajurs bore the title "al-Turki", i.e., "the Turkish".

The early date of these observations may be brought into prominence by noting that they took place before the foundation of the Sharaf ad-Dawla Observatory and that, likewise, they antedated such first-rate and early observation activities as those of Abdurrahman as-Sufi and Abu'l-Wafa. In fact, the activity of the astronomers of the Amajur family was preceded, among similar major undertakings, only by the observations conducted by Al-Mamun and those made by the Banu Musa Brothers, the observations of Al-Battani having been carried out practically during the same period as those of the Amajur family.

The remarkably long stretch of the observation activity of the Amajurs, extending over nearly fifty years, did, very likely, not constitute an uninterrupted sequence of work. It should be noted, nonetheless, that it was lengthier than the life span of any of the major Islamic observatories mentioned above, with the sole and possible exception of the Maragha Observatory.

Only two other specific examples of great interest, concerning early medieval Islam, will be touched upon here. Abu'l-Fadl 'Abdulhamid ibn Wasi’ ibn Turk was apparently the first Islamic mathematician to write a book on algebra. Indeed, he, very likely, wrote his algebra before Al-Khwarazmi wrote his. For, unlike Al-Khwarazmi, he wrote an unabridged algebra, and, moreover, there is evidence that Al-Khwarazmi was still alive at about the middle of the ninth century. Abdulhamid ibn Turk was also the author of certain books on numbers, on commercial arithmetic, and on the art of calculation, probably with the decimal system.

The fields of algebra and calculation with positional decimal system of numerals were fields in which Western Europe received important influence from the World of Islam. This influence was transmitted especially through the translation of the works of Muhammed ibn Musa al-Khwarazmi.
Abu'l-Fadl 'Abdulhamid ibn Turk was either a contemporary of Al-Khwarazmi or of slightly earlier date. He must have lived therefore during the reigns of Harun Rashid and AI-Ma'mun. His grandson Abu Barza was also a mathematician and likewise bore the title "ibn Turk". AI-Khwarazmi too may have been a Turk, as his native land was Khwarazm where Turks constituted a considerable part of the native population. The likelihood that Al-Khwarazmi was Turkish is enhanced by the fact that he vas apparently sent on an official mission to the Turkish Khazars.

Such examples of early date clearly show that Turks not only contributed substantially to the continuation and progress of scientific work in Islam, together with the Arabs and Persians, but that, like them, they also took part in the pioneering work of laying the intellectual foundations of the Islamic culture and civilization at its initial and formative stages. They thus figured prominently, in a more general context, among the artisans and architects who brought the Islamic World to the forefront of the domain of world civilization and raised it to the position of the torch bearer of knowledge from which the Christian West received the light and inspiration with the help of which the Dark Ages became a thing of the past. During the twelfth century in special Arabic works on science, medicine, and philosophy were translated into Latin as a result of intense and systematic efforts centred and organized in Toledo and Sicily. The importance of this process of appropriation of the legacy of Islam by Western Europe is brought into relief by giving the name "the Renaissance of the Twelfth Century" to this period of translation, implying thereby that it is quite comparable in importance, in the intellectual history of Europe, to the Renaissance of the sixteenth century.

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But there is also the question of further Islamic contributions during the era extending from the thirteenth century to the sixteenth and seventeenth centuries, i.e., of indirect contributions of Islam to the rise of modern science in Europe. In other words, although Islam did not produce the Copernicuses, Vesaliuses, Harveys, Galileos, and Keplers of the sixteenth and seventeenth century scientific revolution and even though the decisive achievements leading to the rise of modern science were materialized in Europe only, yet Islam would seem to have contributed to a limited extent and in a roundabout manner to the actualisation of that scientific revolution, and Turks were undoubtedly the most important element in Islam in the transmission of such influences.

Contacts of Europe with Islam were sharply reduced with the close of the 14th century CE. But there is evidence that after the later centuries too cultural contacts of intellectual significance between Islam and Europe continued to be of a magnitude that was by no means trivial or negligible.

> *There were Christian and Jewish communities and also important places of pilgrimage within the Islamic territory. Moreover, the time of the Ilkhans and the Ottoman era, especially the reigns of Muhammed the Conqueror and Suleyman the Magnificent marked periods of increased contact with Europe. By the beginning of the sixteenth century the whole of the Balkan Peninsula had come under the Ottomans, and Turkish rule had penetrated into the heart of Europe. It is reasonable to think that these circumstances too were conducive to the growth and enhancement of cultural relations between the two realms.*

Figure 4: A miniature portrait of Mehmed II by Sinan Bey (Topkapı Palace Museum Library, H 2153).

In the Ptolemaic theory of the solar system, which had reigned supreme throughout the Middle Ages in Europe as well as in Islam, the model used for the moon resulted in a variation of the distance of the moon to the earth which was conspicuously exaggerated. It is of great interest from the standpoint of the repercussions of Islamic astronomy in Europe that the model used by Copernicus to correct this glaring discrepancy of the Ptolemaic model with observed facts was based on the use of secondary epicycles in the

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same way as they were utilized some two hundred years previously by the Islamic astronomer Ibn ash-Shatir.

Parallelism also exists between Ibn ash-Shatir's and Copernicus' model serving to account for the motions of Mercury and Venus. As Copernicus generalized the use of Ibn ash-Shatir's double epicycle device by applying it to planetary motions, Ibn ash-Sha,tir's model for lunar motion is considered to have served as a source of inspiration for Copernicus.

According to Copernicus' younger contemporary and close associate Rheticus, Copernicus' reflections on the changes observed in the brightness of Mercury contributed towards the creation of his system. It is noteworthy that a device used by Copernicus in connection with Mercury is also of Islamic origin.

In Ptolemy's model for Mercury one of the constituent motions took place along a straight-line segment. Copernicus replaced this by a device consisting of two circles, the diameter of the smaller being equal to the radius of the larger one. The small circle rolls within the larger one, always remaining tangent to it. As in such a device a point on the circumference of the small circle traces a straight line which is a diameter of the larger circle, the device serves to convert uniform circular motion into an oscillatory motion along a straight line, or, rather, to represent a translational motion with the help of uniform circular motions.

Copernicus used this device to transform the translational motion in the Ptolemaic model into uniform circular motion that was deemed more appropriate for stellar bodies. This device had been utilized and perhaps also thought out by Nasiruddin at-Tusi, the director of the Maragha Observatory founded by Hulagu.

It is of great interest also that Copernicus' parallactic ruler was not fixed but could revolve about its vertical axis. This instrument was, either the first European example of its kind, or the second such example, the first use of it having been made by Regiomontanus shortly before the time of Copernicus.

The revolving parallactic ruler also reveals unmistakable Islamic influence upon Europe. It made its first appearance in the thirteenth century in Islam. It was among the instruments designed for the Maragha Observatory, and about a century and half later Ghiyathuddin Jamshid al-Kashi (or Kashani) used such an instrument in Samarqand where he worked in Ulugh Bey's Observatory. In Europe it is later on seen among the instruments of Tycho Brahe.

Ghiyathuddin al-Kashi is said to have thought of a new method with the help of which to measure the parallaxes of the lower planets and to apply it to Venus. As these planets are not visible at their culmination, he is said to have proceeded as follows, in Samarqand. He found the latitude and longitude of Venus for a given time shortly before sunrise or shortly after sunset and calculated its true altitude from these values of latitude and longitude. He then found its azimuth from this altitude, and fixing a parallactic ruler at this azimuth, he measured the apparent altitude of Venus. From this, finally, he deduced its parallax.

Two of the methods for measuring parallaxes of comets attributed to Regiomontanus are based on measurements of elevation and azimuth at two positions making acute angles with the meridian. The measurement of elevation at directions outside the meridian brings to the mind the method, just

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mentioned, of Ghiyathuddin for determining the parallaxes of the inferior planets. It is possible that the latter's method had inspired Regiomontanus, and Regiomontanus may have had recourse to the revolving parallactic ruler for making the measurements in question.

Parallelisms have been found between the trigonometry of Regiomontanus and that of Nasiruddin at-Tusi as well as of Ulugh Bey's circle. Again, Ghiyathuddin Jamshid al-Kashi (d. 1429-30) gave an example of the use of positional decimal fractions in a period in which similar individual examples of it are encountered in Europe.

The mathematicians Mordecai Comtino (d. 1487) and Elia Misrahi (1456-1526) were well familiar with the Ottoman capital, and, in fact, they both died there. Mordecai Comtino gave the example of the use of positional decimal fractions, and Misrahi is known to have brought along with him, in his trip form Istanbul to Basel, a book containing certain important summation formulas. The knowledge of such formulas had been much developed and enriched in Islam through the work of Ghiyathuddin al-Kashi especially, and such mathematicians used summation formulas as Bonaventura Cavalieri (1598-1647) in connection with their work paving the way towards the emergence of the integral calculus.

How did, for example Copernicus gain access to the knowledge of such things as the Nasiruddin at-Tusi device for converting circular motion into a rectilinear one and the Ibn ash-Shatir model of double epicycle? Apparently none of these were to be found in European texts. Such ideas must in part have travelled and been transmitted orally and by elusive routes very difficult to determine with any degree of certitude in their full details.

Important books on astronomy were written in Eastern Islam during the period extending between the time of Nasiruddin at-Tusi and the end of the sixteenth century. And they were apparently well read and far from being merely committed to the shelves. Unbroken lines of astronomers were produced, and substantial commentaries to the more important works were composed. One finds, e.g., Nasiruddin's above-mentioned device described and explained in several fourteenth and fifteenth century books on astronomy.

In the period spanning the life times of Regiomontanus and Copernicus there were at least two astronomers of note in Istanbul. They were both well versed in mathematics as well as in theoretical and practical astronomy, and they were productive writers. They were Ali Qushji (d. 1474) and Mirim Chelebi (d. 1525). Istanbul, on the other hand, with its active commercial dealings especially in maritime trade and its thriving Venetian, Genoese, and Ragusan colonies, was a metropolis well suited to traffic in ideas and cultural contacts between the East and the West.

Several Italian painters and men of letters are known to have visited Istanbul and to have stayed there for periods of different lengths. Gentile Bellini resided in Muhammed the Conqueror's court for some months during the years 1479-1480. In the opening years of the sixteenth century Leonardo da Vinci designed a plan for a bridge to be built across the Golden Horn in Istanbul. His plan as well as a letter concerning it has been preserved to our day.

Regiomontanus was a contemporary of Ali Qushji and Muhammed the Conqueror, and Copernicus was a contemporary of Mirim Chelebi and Suleyman the Magnificent. Suleyman the Magnificent ruled from 1520 to

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1561, and during the early years of his reign diplomatic activity of the Ottomans with all parts of Europe reached a high pitch.

Examples of cultural contacts of a similar nature but running in the opposite direction are likewise not lacking. The map of America by Piri Reis, an admiral of Suleyman the Magnificent, is a clear witness of fruitful cultural relations between the East and the West, this time Ottoman Turkey being on the receiving end.

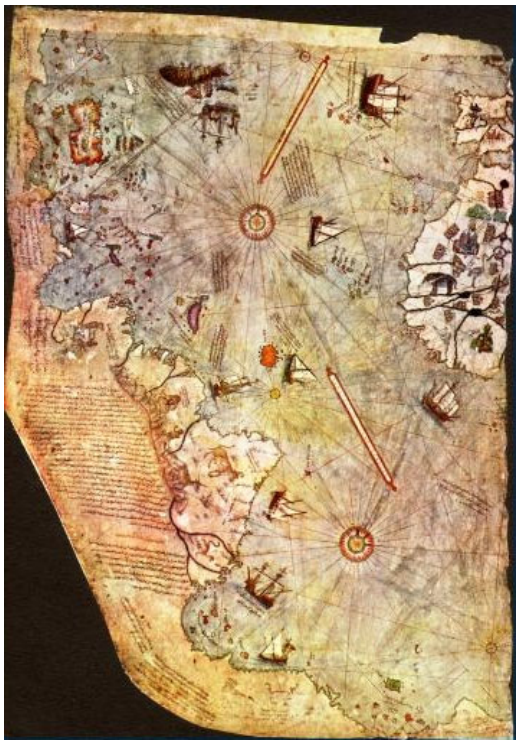

Figure 5. A section of the World Map produced by Pîrî Reis and presented to Sultan Selim I in 1517.

It has been claimed that the ideas of Ibn al-Nafis of the thirteenth century influenced the discovery of the circulation of blood in Europe. This is probable indeed, as Ibn al-Nafis' book containing the first description in history of the pulmonary circulation was translated into Latin in 1547, i.e., several years before the publication of the same discovery by Michael Servetus and Realdo Colombo.

It is quite possible too that the tracer whose invention is attributed to Sanctorius (1561 -1636), and sometimes to certain contemporaries of his, was not unrelated to the similar instrument used by Sabunjuoglu Sherefuddin, fifteenth century Turkish physician and surgeon of Amasya. The probability of such a relation gains added strength from the fact that they both had also the syringe and the permanent probe and that Altunjuzade (or Altunizade), a contemporary of Sharafuddin, also had some such instruments. But the case is complicated by the possible priority of Abu'I-Qasim az-Zahrawi (d. ca. 1013) in these matters. This would again involve the problem of Islamic influence upon Europe, but in this case the influence in question could go back to a much earlier date. It is of interest in this connection that Sanctorius had been to Hungary and Croatia, so that he must have been in rather close contact with Ottoman medicine.

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Nasiruddin at-Tusi's ideas on Euclid's parallel postulate became available in Europe in Latin translation in the middle of the seventeenth century. This is said to have influenced the substantial work of Girolamo Saccheri in the eighteenth century, clearing the way for the appearance of non-Euclidean geometry.

Interesting similarities have come to light between the instruments of Taqiyuddin in Istanbul and those of his contemporary Tycho Brahe. Tycho Brahe's Uraniborg Observatory was built in 1576, i.e., only one year after that of Taqiyuddin. They both had the mural quadrant, the azimuthal quadrant, and a "wooden quadrant" with common special features. Both astronomers had, moreover, the armillary sphere and the parallactic ruler.

Figure 6. The Portrait of Sultan Selim III (1789-1808).

Most of these instruments can be traced back to Ptolemy, but they had been improved in Eastern Islam and acquired new specific features, adapting them to the needs of large-size observatory instruments. The Tychonic instruments were of this later Islamic variety, so that they are linked up and tied to those of late medieval observatories of Islam with very tangible and clear bonds of historical continuity.

Parallelism and continuity is likewise found between the other early observatories of modern Europe and those of late medieval Islam in many particulars and points of detail. There should be no doubt indeed that the modern observatories of Europe actually grew out of the observatories of the Turkish-Islamic World.

With the passing of centuries Europe made great strides in science and industry, and it was now the turn of the Islamic World to turn to the West to increase its knowledge, reform its institutions of science and learning, and modernize its industry. In fact, such a procedure had to be adopted eventually by the rest of the world too, e.g., by Japan, China, and India.

It should be noted here, even if very briefly, that outside of Europe, the first example of such a movement of importing Western science was given by Ottoman Turkey. This started with the opening, in Istanbul, of a naval engineering school in 1773-4 and of an army engineering school in 1795 by the Selim III reign. During the nineteenth century this movement of Westernisation continued in Ottoman Turkey in various

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other fields and on a progressively broadening scale, and Muhammed Ali Pasha of Egypt carried out the same sort of reform during the second quarter of the last century and in Iran in a somewhat later era.

Turks are thus seen to have played an active part in the pursuit of science and learning in the Islamic World throughout its history. This activity started at the very formative stages of the process of building a historically momentous world civilization and continued, with its various turns of fortune, down to the present day.

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