[168] In the two preceding chapters I have tried to draw a provisional picture of the role of the Islamic culture and how it unexpectedly entered the stage of world history in the early 7th century AD and quickly reached the threshold of its own creativity on the basis of resolute and intensive reception of the sciences of the preceding and neighboring cultures—a reception that was supported by the state and not disturbed but promoted by religion. Knowledge, procedures, theories and instruments inherited or taken over from other cultures were not only used and developed further but enlarged enormously and brought to a significant culmination through inventions and creation of new areas of knowledge. Yet one also has to take note of the historical reality that around the middle of the 16th century creativity began to slacken and, leaving aside a few exceptions, came to a standstill around the turn of the 16th to the 17th century.

The characteristic features of scholarship in the Arabic-Islamic world included a clear concept of a law of evolution in the area of sciences, the custom of not hiding sources but citing them with almost scrupulous precision, an ethic of fair criticism, the use of experiment as a systematically employed tool in investigation, the formulation and enlargement of scientific terminologies, attention to the principle of balance between theory and practice, and astronomical observations over many years with the help of the observatories built during Islamic times. With the foundation of universities these characteristic features and principles found their most eminent places for cultivation.

The second of the preceding chapters outlined basic features of the phenomenon of reception and assimilation of Arabic-Islamic sciences and of the Arabic translations and revisions of Greek works that took place in the Occident outside Muslim Spain. The process began, as far as we know, in the second half of the 10th century and lasted some 500 years. The beginning of the creative phase in Europe seems to lie in the early 16th century; then, after about another century, Europe assumed the leading role in the history of sciences.

Not infrequently an interested layman who has found out through reading or from hearsay about the achievements of the Arabic-Islamic culture asks an Arabist or an historian of science about the reasons for the noted stagnation of this culture. The question is worded in different ways and can run like this: If the Muslims were so advanced in the history of science, why are they so far behind now?

To answer this question a symposium was held in Bordeaux in 1956 and [169] a seminar in Frankfurt in the same year with the main emphasis on the same question. The phenomenon that interests us here was discussed in both events by many Arabists and historians of science under terms like “déclin culturel”, “décadence”, “ankylose”, “Kulturverfall” or “Kulturzerfall”.

They are interesting contributions with original ideas from the representatives of various disciplines, searching in their respective field of specialisation for the reasons of the “décadence” or the “decay”, attempting to explain it with due caution and discretion. That so many and widely diverging explanations were brought forward can plunge the reader, particularly a layman, into deep confusion.

Yet we must consider that roughly fifty years ago the conditions for the discussion of this theme were considerably more unfavorable than they are today. Leaving aside the fact that the significance of Arabic-Islamic sciences had not nearly been sufficiently clarified on the basis of individual research, those scholars lacked certain overviews and general descriptions that we have at our disposal today. Within the limited framework of the present treatment of the theme, we do not wish to discuss the explanations and attempts at explanation in those contributions. We may single out just one remark by Willy Hartner, the only historian of science among the participants of the discussion.

Having “outlined the essential stages of the upswing and the decline,” Hartner says: “George Sarton often spoke of the ‘wonder of Arabic culture’ and with this word pointed to the difficulty or even the impossibility of showing the reasons for its upswing. In fact I also do not know an obvious answer to this question.”

By contrast to this understandable caution, I take the liberty of enumerating the factors that can have been involved in the matter, of which I have become aware during my pursuit of the history of Arabic-Islamic sciences.

1. In early Islam the Arabs were obviously in a mood of awakening and confident of victory, and parallel to this they were full of intellectual curiosity and had a thirst for knowledge and were receptive.

2. The new religion, reflecting this spirit, did not hinder sciences, but promoted them.

3. Umayyad, Abbasid and other statesmen supported sciences in many ways.

4. The cultural representatives of other religions, after the conquest of their homelands by the Muslims, were treated properly, respected and made partners of the new society.

5. Already from the first century onwards there developed in Islamic society a special, fruitful teacher-disciple relationship unknown to the Occident in the Middle Ages and beyond. The pupils did not study from books only, but under direct instruction from the teacher. This facilitated the process of learning and assured reliable knowledge.

6. Natural sciences and philosophy, philology and literature were cultivated and pursued from the outset in a secular manner and not for theological purposes. The pursuit of sciences was not the privilege of the clergy but was open to all professions. Thus in the bio-bibliographical literature the surnames of most of the scientists of the Arabic-Islamic area are designations of professions like tailor, baker, joiner, smith, camel-driver or watchmaker.

7. As early as in the 1st/7th century a system of public instruction began in the mosques. In the 2nd/8th century [170] eminent philologists, men of letters and historians had their own professorial chairs (called usṭuwāna “pillar”) in the main mosques. The reports that have come down to us about the methods and manners of lectures and discussions testify to the high academic style of these teaching institutions. These mosques developed spontaneously into the first universities until state universities were founded in the 5th/11th century.

8. The character of the Arabic script permitted easy and fast writing and because of that made possible a wide dissemination of books.

9. A philology that developed fast and thoroughly provided the scholars with a solid base.

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for writing their treatises and acquaintance with foreign languages.

10. The acceptance and appropriation of foreign terminology sharpened the insights into exact definitions and scientific precision and led to the creation of specific Arabic technical terminology.

11. The written tradition found the support of the traditional papyrus industry that had already been expanded in the first century of the Hijra, and later on through the foundation of factories for the manufacture of paper as writing material that had been adapted from the Chinese and had found enormous circulation in the Islamic world (infra p. 175 ff).

12. It was also very useful that a better and longer lasting ink was developed in the 4th/10th century from an admixture of ink made of iron-gallic (gall-nuts, vitriol, gum Arabic and water) with soot, which made possible a deep-black script that was non-fading and durable, without becoming pale or brown over the course of time.

With full justification we can maintain that all these factors contributed to a fast, broad and thorough development of the sciences in Arabic-Islamic culture and remained effective not only for a short span of time but for centuries. It is unfair to speak frequently of religion in general or of orthodoxy, theology or mysticism in particular as having had a detrimental impact on science. Such reflections do not take into account the fact that the well-known initial upsurge in the development of Arabic-Islamic sciences continued for centuries without interruption and that the creativity did not slacken until the 16th century.

On the contrary, it should be pointed out that one did not have to fear any reaction from theology when calling Aristotle for centuries the “first master” (al-mu‘allim al-auwal); and often it was the custom to add the honorific “distinguished” (al-fāqil) while mentioning the names of the great Greek scholars like Archimedes, Galen or Apollonius. But that did not mean that this respect prevented anybody from criticising their Greek teachers. That did happen indeed, only one had a certain ethic of criticism: not to be unfair, exorbitant or arbitrary. Three examples may serve to clarify this:

The first example deals with the three Mūsā brothers (Banū Mūsā, 1st half of the 3rd/9th c.). They improved the book by Apollonius of Pergae on conic sections in some passages and furnished it with proofs, postulates and theorems. Some [171] 150 years later the great mathematician and astronomer Abū Naṣr b. ‘Irāq defended Apollonius with the remark that the Banū Mūsā had been wrong in a few cases.

As a second example, we may cite the criticism which Ibn al-Haïtam levels at Ptolemy by accusing him of having consciously made allowances for errors in order to save his planetary models which he had recognised as false: “These passages we have cited are those with obvious contradictions which we have found in the Almagest. Among them are some that are excusable but also such that cannot be excused. It has to do, on the one hand, with oversights which can happen to anybody and which are excusable, but then there are passages in which he committed mistakes knowingly, as in the case of the models of the five planets, and those are inexcusable.”

4 This view is opposed by a tendency noticeable in recent years among some scholars who study Arabic as a secondary subject and hold the Arabic-Islamic culture in certain contempt; they are of the opinion that the Arabs had to import their paper from Italy. For, the Arabs are not generally credited with creativity in the history of science and it is believed that one cannot ascribe to them any influence in the scientific upswining in Europe.

5 I owe this information to Dr. Armin Schoppen, the author of: Tinten und Tuschen des arabisch-islamischen Mittelalters. Dokumentation – Analyse – Rekonstruktion, Göttingen 2006.

6 v. F. Sezgin, op. cit., vol. 6, p. 137

7 Ibn al-Haïtam, aš-Sūkāk ‘alā Batlamiyūs, Cairo 1971, p. 4; F. Sezgin, op. cit., vol. 6, p. 86.
As a third example, we may mention the attitude of the above (p. 35) mentioned mathematician Ibn as-Salah who followed up almost systematically the criticism of the Greek scholars by his Arabic predecessors, testing its justification and not infrequently defending the former against their critics.

It is indeed conceivable that a reader who is well versed in Arabic literature remembers at this point the work by Abû Hâmid al-Ħazzâli (d. 505/1111) entitled *Tahâfut al-falâsifa* in which he refutes some of the views of Greek and Arab philosophers, including those of al-Fârâbî and Ibn Sinâ. These refutations reveal the scepticism that an orthodox theologian acquired after a thorough study of philosophy. Even though al-Ħazzâli reacted strongly in the matter, he avoided abuse; moreover, this was above all an individual reaction and not an institutional one. Official opposition and condemnation like that of Averroes at the university of Paris or the Aristotle-prohibition by Pope Innocence III in 1209 would have been inconceivable in the Islamic world.

Perhaps it is not superfluous to point out that the freedom and esteem which the Christian and Jewish scholars enjoyed under the Umayyads and the early ‘Abbâsids and their participation in the scientific upswing continued uninterrupted in later centuries as well. Moreover, they could assume important functions in the state and move freely from Persia to Andalusia and could practise their profession wherever they wished, leaving aside a short period of intolerance under the Almohads in Cordoba. The personal physician of the ruler al-Malik an-Nâšir Šalâhaddin (Saladin) and of his son al-Malik al-Afdal was the famous Jewish physician and philosopher Ibn Maimûn (Maimonides, d. 601/1204). From the middle of the 6th/12th century it is reported that in Baghdad there were three great physicians called Hibatallah: the Christian Hibatallah b. Šâ‘id Ibn at-Tîlîmî, the Jew Abu l-Barakât Hibatallah b. Malikî and the Muslim Hibatallah b. al-Husain al-Èsfahânî. Among these three, the Christian Hibatallah, who was the director of the ‘Aṣâḍî hospital and was mayor of the Christian community, was appointed by Caliph al-Mustâdi (r. 566/1170-575/1180) spokesman of the medical profession and was entrusted with the professional examination of the medical practitioners in Baghdad and its vicinity. For the Arabic-Islamic culture it was not unusual that the Muslim and historian of medicine Ibn Abû Usâbi‘a as well as the Christian historian Ibn al-Èibrî wrote in the 7th/13th century about these three physicians belonging to different religions without any discrimination and with great appreciation. How important the atmosphere of tolerance prevailing in the Islamic world was for cultural history becomes clear when one reflects that in 1241 in the Occident a Christian could be excommunicated if he let himself be treated by a Jewish physician. The preceding explanations and examples shall serve as support for my conviction that Islam is to be excluded as the main reason for the recession or the end of productive scientific activity in the Arabic-Islamic world. I am convinced that religion can hardly endanger the advance of sciences seriously in a cultural circle once the process of upswing has developed its own dynamics and has made its way under favorable conditions. Christianity was also unable to stop the process of the reception of Arabic-Islamic sciences and its further development in Europe after it had begun. In the present case, it means

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9 ibid, pp. 66, 136, 160.
10 v. Ibn Abû Usâbi‘a, *‘Uyûn al-anbâ‘*, vol. 2, p. 117
15 v. H. Schipperges, *Die Assimilation der arabischen Medizin*, op. cit., p. 128
that we have to identify the real conditions and events that were detrimental.

Above all one has to keep in mind that the Arabic-Islamic sciences began reaching Europe from Arabic Spain from the second half of the 10th century through translations and through technical instruments and devices. About a hundred years later a second path to Europe opened up via Sicily and southern Italy. Then it became of fundamental importance that the Europeans decided to fight against the Islamic world, shortly before the end of the 11th century. The eight wars known under the name of the Crusades lasted from 1095 to 1291. In these military expeditions, which ended once with victory, another time with defeat, the Europeans were in reality always the winners and the beneficiaries. The wars weakened the Islamic world not only in its economy but hindered the process of the scientific development and, through the occupation of parts of Palestine—like a wedge in the centre of the Islamic world—disturbed the circulation of new achievements and of books.

According to the level of our knowledge, the Muslims of those times were far superior to the occupiers in technical knowledge as well as sciences. The occupiers had hardly anything equivalent to contribute. The Muslims, urged on by the spirit of defence, seem to have made noteworthy advances, above all, in the development of weapons such as the windlass crossbow and the counterweight catapult, canons, hand grenades and hand firearms as well as the in use of steel stirrups. But, in the long run, the countries of the crusaders profited more from this progress in the technology of weapons than the inventors themselves. All these new inventions in weapon technology were to be found again in Europe in a time span of about fifty years. There can hardly be any doubt that the weapons and the knowledge of their use and manufacture could reach Europe so quickly mainly through the crusaders.

At the same time when a central area of the Islamic world was suffering under war and occupation by the crusaders, the invasion of the eastern parts by the Mongols began in 613/1216. During the approximately seven years of attacks by the Mongols on Persia that ended in 628/1231 with the conquest of most of the country, many native places of culture and centres of the sciences were devastated. [173] The central part of the Islamic world experienced further destruction in 656/1258 through the conquest of Baghdad by Hülegü, the grandson of Čengiz Han, and through the subsequent conquest of large parts of Syria.

With the conquest of Constantinople (857/1453), the Ottomans had taken over the leadership in the largest part of the Islamic world. With all their ventures of expansion they did not neglect to look after education and science in their empire, and there was no lack of scientific creativity there until the end of the 16th century. Yet the Ottomans were fighting a losing battle, in view of the new situation brought about by the Portuguese and the Spaniards. Of devastating consequence for the leading role of the Muslims in world politics and in the sciences was the loss of Portugal and a significant part of Spain with Toledo in the second half of the 11th century. Thereafter their political presence in the west of the Islamic world diminished progressively until the fall of Granada in 897/1492. After this final loss, the Iberian peninsula with its centres of sciences where Muslims had done important work for centuries was no more counted as a part of the Islamic world, but rather belonged to the Occident. But it should be noted that it was once again Spain and Portugal which—after belonging for a long time to the Arabic-Islamic area—assumed the political as well as scientific leadership on the world stage, before they had to yield place to other western and central European countries at the beginning of the 17th century, at a time when there was also a shift of power in the Arabic-Islamic world.

One should also consider the world-wide political and economic consequences of the discovery of America which could be accomplished by
the Spaniards only thanks to the nautical, technical, astronomical and geographical knowledge that they had appropriated over centuries from the Arabs. That the Spaniards came to discover the fourth continent towards the end of the 15th century should be understood in the sense of the continuity of Arabic-Islamic sciences in Europe. This continuity thus reaped its first fruits under the newly given conditions. With a clear idea of the spherical shape of the Earth and of its size, the Arabs undertook daring voyages even before 1050 AD while they ruled in Portugal, in order to reach Asia, which they knew well, from the western coast of Europe across the great “encompassing ocean”. The ventures must have been repeated so often that one street in the harbour of Lisbon was called Darb al-magriirin (“street of those who go astray”).

We do not know whether anybody reached their goal in such an early period when no compass was available for the purpose of navigation, or none that was adequately developed; but the Spaniards, having made themselves politically independent of their Arab predecessors, felt in a position to do so. Although they did not know al-Biruni’s (d. 440/1048) indication that the ocean that encircles the inhabited continent might perhaps separate this from a continent that lies further beyond or from an inhabited island, such Christopher Columbus had at his disposal compasses as the Arabic navigators had developed in the Indian Ocean. Even more than this factor, there were two further elements that encouraged Christopher Columbus and made easier his decision to reach India not by the south African route but from the west. The one element was that he adhered to the values of the Arab measurement of the Earth with 56 2/3 miles for one degree, though believing however [174] that the Arabic mile and the Italian mile were the same and both amounted to 1525 km. Accordingly his notion of the circumference of the Earth was too small by about one-fourth. The second encouraging element was the bizarre idea of a pear-shaped Earth through which the path to India from the west would also be made particularly shorter. This incorrect notion was already pointed out in the first half of the 19th century by the famous natural scientist Alexander von Humboldt. The discovery of America was an epoch-making geographical and nautical success that would have been unthinkable but for the long presence of the Muslims on the Iberian peninsula, and inconceivable without the navigation developed by them and the enlarged geographical knowledge, as was already stated by Joseph-Toussaint Reinaud a century and a half ago.

With Granada, the Arabs lost in 1492 not only the last bastion of their 800 years’ rule of the Iberian peninsula, the loss marked at the same time the beginning of the final end of the Arabic-Islamic world power. Of course the Ottomans were politically in a position to extend their rule over large parts of the Mediterranean, the Balkans, the area around the Black Sea with the Ukraine and the Caucasus and over the Arab countries up to the Arabian peninsula and northern Africa. The Safavids were still a respectable political power in Persia in the 16th century, and the Islamic Moghul Empire established in India in 1526 possessed even more significant political
and economic strength. Moreover, the sciences in these three great Islamic empires were still of a high level. Yet the existing balance of power could not have lasted longer after the Islamic world had lost its central geographic position in the old inhabited quarter of the globe through the discovery of America and the appearance of the Portuguese in the Indian Ocean.

In order to understand fully the reasons for this turning point in history, we must also take into consideration the importance of the expeditions around Africa and into the Indian Ocean by the Portuguese, which too began towards the end of the 15th century. In this context, it is of great significance that of all the Europeans it was the Portuguese, whose country had been under Arab rule for four hundred years, who now assumed the role of pioneers on this route. However, it shows an insufficient knowledge and a lack of appreciation of historical reality when one calls the laudable and successful undertaking of these voyages the “discovery” of the sea-route to India and to the Cape of Good Hope, in the sense of a purely Portuguese descobrimento. Herodot already reports about a Phoenecian circumnavigation of Africa on the order of Pharao Necho (ca. 596-594 BC). In Islamic times the circumnavigation of Africa was not only a well known fact but there was also a trade route between south Morocco and China. It is a contradiction of a reality of history of science to consider the Portuguese as the founders of a new kind of navigation that enabled them to circumnavigate Africa and to navigate the Indian Ocean unhindered. Now we know quite well that during Arab rule a regular and active navigation existed between the western coasts of the Iberian peninsula and the northwest coast of Africa, which lasted until the rule of the Almohads [175] (1130-1269). In the tradition of this navigation, with the knowledge of the previously sailed sea routes and with the possession of Arab maps, the Portuguese were the first Europeans to reach India by the sea route, and they played a leading role in the Indian Ocean for about a hundred years, thanks to Arab pilots and to locally available perfect regional maps and general maps with information of distances and thanks to a highly developed navigation.

Of course, the Portuguese were initially inferior to the Arabic-Islamic culture in all fields of science for almost a hundred years, but they gained many victories through their uninterrupted expeditions that were motivated politically, economically and for religious reasons and were militarily well prepared. During their invasions lasting more than half a century—even if they were not always victorious—they destroyed the weak Arabic fleet and the Turkish-Ottoman fleet coming later to the succor of the Arabs, they devastated or conquered the coastal areas of the Red Sea, of Southern Arabia, of the Gulf of Persia, of India and the Malay Archipelago, and transported the natural wealth to Portugal. Since the middle of the 16th century the Portuguese made themselves masters of the Indian Ocean that had been for centuries like a land-locked sea for the Islamic world. With their rule and the rule of other Europeans over this area and with the discovery of America, the political, economic and strategic landscape of the world changed totally to the disadvantage of the Arabic-Islamic world. The new economic and military strength thus acquired did not remain limited to Spain and Portugal only but was of advantage to the other European countries as well so that the balance within Europe changed over the course of time.

With these explanations about the upheavals on the world stage brought about by the Spanish and the Portuguese, I follow the aim of demonstrating in a few concrete examples my ideas for the reasons behind the stagnation of creativity.

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20 v. ibid, vol. 11, pp. 384, 389 ff.
in the Arabic-Islamic world. Here we encounter the oft-repeated historical maxim that a culture that was dominant in sciences in its time has to make way for a successor whom it had encouraged and whom it had provided with the weapons with which it is now defeated.

For the illustration of this historical sequence, I see an instructive example in the history of paper which the Muslims on their part, having adapted it from other cultures, developed further, giving it to the Europeans and importing it later again from them. The research hitherto could trace this development to a large extent. I cite first from Alfred von Kremer’s *Culturgeschichte des Orients unter den Chalifen* from 1877 which, despite its age, is a masterly exposition that has hardly been surpassed. In the earliest period of the Islamic society, he says, “one wrote on the hide of animals, well prepared or not so well, on parchment or also on leather which originated in the factories of South Arabia and which excelled through smoothness and fineness. But soon papyrus came into use, since at the conquest of Egypt the Arabs found there a highly developed industry dating from ancient times in the processing of the papyrus plant into writing material. This industry underwent an upswing through the Arab conquest because, as was noted earlier, the old Mohamedan state and administrative laws did not prescribe any tax on crafts and factories. The main seat of this industry was in the Delta, to be precise, in the small town of Būra, a place on the coast in the district of Damiette. Here the papyrus plant that probably grew in plenty in the nearby Menzaleh Lake, was processed and offered in the market. The Arabs even kept the old name of the plant and called it Fāfir, while the product manufactured from it was called Kirtās after the Late Greek cártā.”

“But in the eastern Roman empire where the Byzantine civil service had become extremely fond of writing, as well as in the Occident, the Saracenic factories of Egypt were the only source of supply; consequently there was an extremely brisk export of papyrus to Byzantium for which the price had to be paid in ready money. However, it seems that another type of preparation of paper from other materials was invented in Egypt quite early; otherwise it would be difficult to explain the statement by an old writer to the effect that Caliph Mo’tasim who, in his newly built residence in Sāmarrā, settled artisans from all parts of the empire, also let manufacture workers of paper (kirtās) come from Egypt to Sāmarrā. But the papyrus plant is totally absent there; consequently the production of paper could only have taken place from other materials: from cotton or linen. The Arabs learned the use of the latter material for the preparation of paper only later; consequently there remains hardly any other explanation possible than to assume that in the Egyptian factories, with the cultivation of cotton propagated by the Arabs, one began gradually to adulterate true papyrus with cotton, by which process one finally came to the discovery of manufacturing paper from cotton only …”

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23 vol. 2, Vienna 1877, pp. 304 ff.


"But in the period from the beginning of the IIIrd to the middle of the IVth century A.H. a great change took place. One began not only to import Chinese paper that was always very expensive, but in northern Arabia (Tihâma) there began a local paper production …"\textsuperscript{19}

"At first an enterprising Chinese brought into the farthest north-eastern province of the Caliph’s empire the art of preparing paper from linen; and in a book dating from the second half of the IVth century (the \textit{Fihrist} of Ibn an-Nadim) we already encounter a longer list of different types of paper from linen. In Samarqand this new industry reached its highest bloom and soon this city became rich and flourished through trade, where the export of paper continued to hold an outstanding position. With the rapid upswing of a national literature and the diligent cultivation of scientific studies, leading to an increased consumption of paper, the production and the trade of this article assumed an enormous expansion; paper factories \[177\] appeared in all places, but it should not remain unnoticed that in the battle between the linen paper of the east and the cotton paper of the west, the victory went to the latter, undoubtedly because one could produce it more cheaply and could thus gain ground against the expensive rival article."

"When the Saracenes gradually conquered from Egypt the entire north African coast, then Spain and finally Sicily, with the cultivation of the papyrus plant which they introduced into Sicily and of the cotton plant which they made native to Spain as well as to Sicily, they also brought with them the paper production that flourished in Sicily as well as in Spain.\textsuperscript{20} The factories of Xativa [Ṣāṭība] were in the XIIth century of our era widely renowned for the types of paper they made from cotton which were also exported into the Christian countries of the west, while the eastern parts of Europe received their paper—doubtless also cotton paper—from the Levant and perhaps also from Damascus, according to the name Charta Damascena under which it was known."

"In the XIth and XIIth centuries this Saracenic product supplanted the old parchment throughout Europe and in 1224 Emperor Frederick II finds himself called forth to ban, as it were, cotton paper for certain official documents because of its inferior durability, but the question of price made such bans ineffective. Only in the second half of the XIIIth century does linen paper appear in Europe which probably seems to have been produced by adding parts of linen to the cotton paper in order to get cheaper varieties; perhaps also an invention of the Moors since flax cultivation was carried out by them widely."

"… Books on parchment or papyrus were so very expensive that they were accessible only to a small circle; since the Arabs produced an inexpensive writing material and delivered it not only to the markets in the east but also to those in the Christian Occident, science was made accessible to all …"\textsuperscript{31}

Subsequent to the paper production that had existed under Arab rule in Sicily, and in continuation of Spanish paper imports in the 12th century, the first attempts were made in the early 13th century in northern Italy at their own paper production; the first results were inferior until the town of Fabriano near Ancona began its own technique which betrayed features of the Arab art of paper making from the area of the east-

\textsuperscript{19} Ibn an-Nadim, \textit{Fihrist}, op. cit., p. 40. Von Kremer adds here that it must have been “obviously nothing else than cotton paper”.


ern Mediterranean and which probably had been brought to Italy by the crusaders. The paper industry that developed in the second half of the 13th century in northern Italy could already hold its own in exports towards the end of the century, rid itself of the Spanish rivals in the first half of the 14th century and win the Arab markets. In this process the business acumen of the Venetians and Genovese played an important role. Since when the Italian paper—leading the market with its advantageous prices—had reached the high quality that distinguishes the extant Arabic manuscripts, I cannot say at present. When I think of the many books known to me which have reached us on that cheap paper and which are no longer usable, then the extent of the loss becomes understandable that came about because of the paper import into the Islamic world.

In order to come to the root of the matter I would like to add an observation that I have made in the course of my pursuit of the history of Arabic-Islamic sciences and their reception and assimilation in the Occident: namely, that in the practical part of technology Europe displayed a remarkably faster ability for reception, dissemination and further development of the received items than in the theoretical sphere. This may be demonstrated in the case of the reception of the above mentioned astronomical instrument which was called an equatorium in the Latin world. As already mentioned, it was invented in the second half of the 4th/10th century by the astronomer and mathematician Abu Ġa’far al-Ḥāzin. After the prototypes constructed by Arab astronomers in Andalusia, it was, according to my knowledge, introduced outside Spain for the first time in 1276 and 1277 through Campanus of Novara. From then on until the middle of the 16th century, many variations were in circulation which were not always faultless but which demonstrated the preference shown to this instrument in Europe. But what is generally striking, in this case as in others, is an exaggerated tendency towards ornamentation, embellishment and not infrequently unnecessary additions that made the instruments heavy and unwieldy. Moreover, the Europeans did not always reach the level of their Arab predecessors in the rudiments of mathematics, and seldom surpassed them. Yet, the circle of those that were interested grew steadily and the interest fostered the creativity. Thus the Europeans reached and surpassed the Islamic world in the technical field earlier than in the theoretical field. With this is connected the next observation, namely that the Europeans stood less in awe of perspective drawing and were more adept at it than the Muslims. Thus they made possible a wider dissemination of manuscripts with technical contents than the Muslims. The advantage on the part of the Europeans became greater through the development of printing in the middle of the 15th century. The possibility of multiple reproductions of technical drawings in printed material also ultimately benefited mechanical engineering and industrial development. Let us consider the effectiveness that the imaginative drawings of Leonardo da Vinci, Georgius Agricola, Agostino Ramelli and others—their connections to Arab sources seem to be unmistakable—could command because of their wide dissemination through printing, while in the Islamic world in the manuscripts of technical books the drawings were often left out in the expectation that a suitable draughtsman would add them later on. Possibly an earlier introduction of printing could have arrested for some time the slackening creativity in the Islamic world.

33 V. J. M. Bloom, Paper before print, op. cit., pp. 210-211.

Be that as it may, we must consider the phenomenon from the point of view of the destiny of the great cultures and civilizations which, when the time comes, must give up their position to the successor whose rise they themselves have prepared. However, it happens not infrequently that an historian, in his attempt to find reasons for this phenomenon, mixes up the causes with accidental events. According to our attempt to find reasons, the economical and political weakness of the Islamic world, brought about by an interplay of wars and the “discovery” of new sea routes, seems to have been the main reason for its stagnation in the sciences. [179] This view is probably not contrary to truth: that the sciences lost their vigour where they flowed freely for some 800 years, and that they could continue to be effective in the Occident to which they had found their way about 500 years earlier and where the climatic and economic conditions for a continuation of creativity were more favorable. In this youngest culture, the radius of which becomes continuously wider, the science inherited from the predecessors develops with great rapidity. In this situation the task of the historian of science is particularly difficult to keep alive the memory of the importance of the past on the one hand, and on the other to revise and correct the prevalent mode of presentation of the historical development that does not do justice to the factual position.