The first two—naturally quite modest—bibliographical studies devoted to books from the "Orient", known in the West through translations, appeared around the middle of the 19th century, at a time when Arab–Islamic science was looked upon with disdain rather than appreciation, as the interests of historians were occupied increasingly by the development of natural sciences in the West. These two works are *De auctorum graecorum versionibus et commentariis syriacis arabicis armeniacis persicisque commentatio* by Johann G. Wenrich (Leipzig 1842) and *Die Übersetzungen der arabischen Werke in das Lateinische seit dem 11. Jahrhundert* by Ferdinand Wüstenfeld (Göttingen 1877). For a long time, basically until today, interest in the question of the transfer of Arab–Islamic sciences—with the exception of certain subjects—was restricted to translators, works translated and extant manuscripts. Yet the issue of the impact of Arab–Islamic sciences as such in the West, be it through translations or through personal contacts, and the assessment of its significance rests mainly on the study of the scientific content of the Arabic (or Persian) writings and thus ultimately on the evaluation of the progress their authors made relative to their predecessors, in particular the Greeks. As shown above, Arabist research has meanwhile achieved remarkable results in the assessment of many surviving works so that a first evaluation in the context of the universal history of science was already feasible and even the question of the impact was addressed on a rudimentary level. The latter was largely limited to individual subjects or issues, only in a few areas was the question of influence treated on a larger scale.

A rare phenomenon in the history of science is the French Arabist Ernest Renan (1823–1892), who dealt with the issue of the reception of the Arab–Islamic sciences in the West in the field of philosophy. Writing his ingenious and admirable study *Averroës et l’Averroïsme* in 1853, Renan had at his disposal only a small number of sources and he could hardly count on the support of his contemporaries. Nevertheless his work has remained valid to some extent until today. Starting with the assumption that in 4th/10th century Spain, Arabic was the common language of Muslims, Christians and Jews, he realised the role of the latter in the dissemination of Arab–Islamic philosophy in [86] Europe. Renan maintained that secular Jewish literary culture in the Middle Ages was nothing but a mirror image of the Islamic culture, just as Jewish philosophy since Maimonides (Ibn Maimūn) had, according to Renan, been nothing but a reflection of Arabic philosophy. The entire school of Maimonides had remained true to the peripatetic tradition of Averroes (Ibn Ruṣḏ). In general, so Renan, Jewish philosophy bore the traits of Arabic philosophy, even after the Jews had

retreated to the Christian cities of Barcelona, Zaragoza, Narbonne, Montpellier, Lunel, Béziers, l’Argentière and Marseilles. In connection with the translation of Arabic works into Hebrew, Renan made the interesting observation that Arabic words were retained or rendered by Hebrew words of the same root, even when these had a different meaning, hence the text was in a way emulated rather than translated. After his masterly description of the process of reception and assimilation of Arabic philosophy in western Europe through Jewish mediation as well as direct translation into Latin, including how this caused hatred amongst the Dominicans and the opposition of Raymundus Lullus, Renan traces the reception of Ibn Rusš’s philosophy in Italy from the beginning of the 13th century. Here too Renan, well-read and witty, draws a lively picture of the scholarly circles who, after three hundred years of studying the Arabic peripatetic teaching, had to endure the anti-Averroës reactions in the 16th century.

How deeply Arabic astronomy and astrology influenced the West was demonstrated best by the non-Arabist science-historian Pierre-Maurice-Marie Duhem (1861–1916) in volumes 2 to 4 of his monumental *Le système du monde. Histoire des doctrines cosmologiques de Platon àCopernic*. Although the great Arabist Carlo Alfonso Nallino in his *Al-Battānī sive Albatenii opus astronomicum* had already paved the way for future research with invaluable hints, yet it is the results Duhem achieved through comparison of available Latin translations of Arabic works of astronomical–astrological content with European works written under the influence of the former, which allow us to comprehend how profound the impact of works translated from the Arabic was, not only on areas of Duhem’s special interest, but far beyond, in the entire cultural history throughout Europe.

In the field of music and musical theory the question of the “Arabian influence” was addressed, fortunately, quite early-on in comprehensive studies. Not even a century had passed since the first surveys of “Arabian” music by R. G. Kiesewetter and J. G. L. Kosegarten, when the Spanish Arabist Julian Ribera y Tarragó in his *La música de las Cantigas* produced a pioneering work on the question of Arabian influences. In the first of the three parts of his book he deals with the history of Arab music in the Islamic world up to the 6th/12th century and in the second part with its history in Spain. The third part is devoted to the author’s main interest, the question of the influence of Arab on Spanish music and on the European troubadours. It is understandable that Ribera’s ideas and results—particularly as regards the question of influences on Western polyphony in the Middle Ages—had their shortcomings, were inapt in many points and could not be left without contradiction.

Three years after the publication of Ribera’s book, Henry George Farmer wrote his *Clues for the Arabian Influence on European Musical

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7 Ibid., p. 185.
Theory\textsuperscript{15}, which caused quite a stir.\textsuperscript{16} The work was promptly criticised by the music historian Kathleen Schlesinger in The Question of an Arabian Influence on Musical Theory.\textsuperscript{17} In 1929 Farmer’s comprehensive study of Arab musical history, A History of Arabian Music to the XIIIth Century, and in 1930 his Historical Facts for the Arabian Musical Influence appeared in London. In the latter he discusses at length, inter alia, K. Schlesinger’s criticism. Ignorant of those comprehensive more recent treatments of the question by Farmer, Otto Ursprung published a sharp response to Farmer’s older works in 1934.\textsuperscript{18}

Farmer’s main topics and hypotheses, referring to Arabian influence and which encountered harsh criticism, are matters of notation and early polyphony, solmisation, musical instruments, lute tablature and metric modes. The discussion of many of these issues centred on the question of whether the new elements in music appearing from the 9th century in the West, go back to Græco-Byzantine or to Arab influences. Of course, Farmer did not deny the Greek basis of Arab musical theory, but he was convinced that the Arabs revised the inherited theories and developed them further. In 1976 two studies appeared on this subject in which Farmer’s conclusions are discussed and elaborated upon. These are Die Theorien zum arabischen Einfluß auf die europäische Musik des Mittelalters by Eva Ruth Perkuhn\textsuperscript{19} and Zur Rolle der Araber in der Musikgeschichte des europäischen Mittelalters by Eckhard Neubauer.\textsuperscript{20} The author of the first study does not oppose the influence-theory in general, but she finds that “in the works on the problem of Arabian influence contributed by ethnomusicologists, methodological and theoretical questions are dealt with in passing, if at all.”\textsuperscript{21} Ribera and Farmer, “the main proponents of the Arabian theory” were “known to be more Arabists than ethnomusicologists” and “hardly acquainted” either with the “practice of Arab music” or with the “problems of cultural anthropology and [88] ethnomusicology”.\textsuperscript{22} Their approach met with harsh criticism\textsuperscript{23} “on the part of music historians who opposed the Arabian hypothesis on emotional rather than factual grounds” and “found a ready field for attacks in such easily discernable theoretical flaws.” According to Ms. Perkuhn, both Ribera and Farmer gave “little consideration to the process of transmission.” Farmer however, “even went a step further narrowing himself down by excluding the ethnomusicalogical aspects, crucial for the research in ‘oral’ transmission and by limiting himself to musical instruments alone.”\textsuperscript{24} Hence she concludes that strictly speaking “the Arabian theory can only be established for the various aspects of music making in the European Middle Ages after research in Arab music culture itself has been thoroughly revised and conventional or dictionary wisdom has been confronted with ethnomusicalogical and cultural–anthropological considerations.”\textsuperscript{25}

The second\textsuperscript{26} of the two works mentioned above was penned by an Arabist and music historian and provides us not only with an adequate assessment of H. G. Farmer’s achievements but
beyond that also with results of more recent research: “In 1930 the musicologist Henry George Farmer summarised current theories on musical influences of the Arabs, put them in focus and added many results of his own research. His *Historical Facts for the Arabian Musical Influence* have encountered fierce hostility but have so far not been refuted.” Issues discussed by Farmer taken up and elaborated upon here include “attempts to notate instrumental music, carried out both by the Arabs and in the European Middle Ages.” They are based on the use of the letters of the alphabet for the designation of scale degrees, as known by the ancient Greeks, and the use of lines for pitch notation, which appears to have originated in Middle Eastern late antiquity. The Arabs wrote down melodies in letter notation and with certain cue syllables or numerals for durations and rhythm; and they did this earlier and more frequently than the few extant documents suggest. An alphabetic tabulature survives from the 10th century, and the *Arabic Great Book of Songs* preserves a report which is to be dated at the beginning of the 9th century about Ishāq al-Mausili… It says that Ishāq sent a new composition to one of his colleagues with written indications of all pitches, durations and phrasings. Thereupon the colleague sang the piece and he sang it correctly without ever hearing it. At the beginning of the 11th century Avicenna [Ibn Sīnā] demanded that a song must not be learnt without first writing it down exactly, with pitches as well as lengths. Most of the extant types of Arab notation refer to the lute [‘ūd]. According to Notker Labeo (d. 1022) and others, the alphabetical notation in the West also originated among instrumentalists and was first used for the *lira* and the *rota*. Hence it appears that both sides originally shared a common tradition. Yet when during Avicenna’s lifetime new concepts of pitch notation were introduced almost at the same time and according to the same principles by Hermannus Contractus (d. 1054) in Byzantium, this rather obviously implies an Arabic model, especially as Hermannus Contractus is known to have been acquainted with Arabic natural sciences.”

“A further step in the development leads us to Guido of Arezzo’s (d. 1050) staff notation. He refers to his three to five parallel horizontal lines as ‘imitation of the string’ and two of these lines are coloured: ‘lustrous saffron is gleaming where the third tone has its place; the sixth, however… glows in vermilion’. While Guido’s sources for what until today has been considered his own achievement remain obscure, Arab practice of using coloured lute strings tuned to certain pitches offers at least a

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convincing explanation for the association of colour and string/line.”

After commenting upon further points which had irritated Farmer’s adversaries, Neubauer continues: “We are on safe grounds again regarding the impact caused by the translation of Arabic texts. In the field of musical theory it is the impulses which the philosopher Abû Našr al-Fârâbî (d. 950) gave through the Latin translation of his Enumeration of Sciences [Iḥṣân al-‘ulûm; De scientiis]. In addition to the familiar division in musica mundana, humana and instrumentalis, in the middle of the 12th century the West became acquainted, through this treatise, with another distinction of musica speculativa and activa—a classification which is derived from the practice of the performing musician ‘which can either be contemplative and exploring (speculative) or active’. It was already known in Greek music theory and was now introduced in elaborated form to the medieval literature where it brought about a significant ‘enrichment of the subject matter’ of theoretical reflections.”

“The translation of Arabic works on natural sciences and philosophy reached its peak in Spain during the 12th and 13th centuries. It is significant that their dissemination coincided with the foundation of the first European universities and largely dominated their curricula. The writings of Avicenna were amongst the most prominent in this development, [90] including some parts of his Kitâb aš-Šiḥâ’ under the Latin title Liber sufficientiae.”

“On the same route, via translations and university curricula—first in Spain, Italy and France—the West was also introduced to the highly developed theory and practice of Arab music therapy. The use of sounds and melodies for restraining emotions occupied an important position in the dietetics of Arab medicine. They had developed their lore from ancient Greek theory and Late Antiquity’s practical experience; they knew that the Persians of the Sassanid period tried to cure melancholy with music and the post-Platonic ethos had far reaching influence… down to the association of lute strings with the fluids of the body.”

In the second half of the 20th century, Heinrich Schipperges earned merits with his numerous treatises and monographs on the reception and assimilation of Arabic-Islamic medicine. In full appreciation of the importance of his various articles, we shall focus here primarily on his two works dealing with our subject on a broader scale. In one of them, entitled Ideologie und Historiographie des Arabismus, Schipperges was, as far as I am aware, the first to tackle the difficult task of assessing the reception and assimilation of Arab–Islamic sciences from the viewpoint of historiography. He begins with the time at which an awareness for the phenomenon had first arisen and traces its development up to the middle of the 20th century. In his comprehensive study Schipperges draws a clear picture of the antagonistic attitude prevalent from the 13th century towards knowledge adopted from the Arab–Islamic world. This in turn caused the current almost total lack of appreciation of this heritage, despite all attempts to do justice to its great importance. For Schipperges hin-
self Arabism is a “phenomenon that has exerted powerful influence over the centuries and still continues to do so and without which we will not understand the configuration of the modern world.”

The second of the two works, entitled *Die Assimilation der arabischen Medizin durch das lateinische Mittelalter* was extremely helpful in our attempt to obtain the most realistic possible picture of the science-historic phenomenon of reception of Arab–Islamic science in the West and its impact. In this work Schipperges concentrates mainly on the question: “How did the reception of Arabic medicine in the Latin Middle Ages take place?” Schipperges frequently uses the term “Graeco-Arabic” for the adopted medicine, meaning the one in the Arab–Islamic area based on the achievements of the Greek predecessors. After defining the subject he initially focusses on the period between the late 11th century and the end of the 13th century, a time when, according to his view, “Arabism” played an important role: “The reception of Graeco-Arabic medicine is considered only from the perspective of the Latin tradition; investigation stops with the translators and their work, it does not pursue the Arabic subject matter, but rather limits itself to the Latin manuscripts.” Schipperges believed it was his task “to question systematically the [91] current notions about the period of reception and thus ultimately the received image of mediaeval medicine in general.” With this goal in mind, he from the onset bypasses the discussion of medical matters and theory. Rather he pursues his aim on the basis of an historiographical survey “on the judgement of the centuries on the question of the importance of Arabic–Latin translations for Western medicine”.

Schipperges assumes the process of reception began in 11th century Salerno in connection with the converted Arab and later monk of Monte Cassino, Constantinus Africanus (ca. 1015–1087), whom Karl Sudhoff in 1930 had called “quite a providential character for the Western medicine.” Apparently, Constantine hailed from Carthage and found his way to Salerno, after a thorough and multifarious study of sciences in Iraq and other countries—as reported by a Western source about 50 years after his death. He carried dozens of Arabic medical books with him or had them sent later. With astounding dilgence and probably also supported by members of his order, he succeeded in bringing into circulation more than 25 of those books in Latin. For the most part he claimed them as his own writings, a few he ascribed to Greek authorities. Most significant amongst these books was undoubtedly the extensive textbook of medicine by ‘Alî b. al-‘Abbâs al-Maţā’sî (d. last quarter of the 4th/10th century) dedicated to the Bûyid prince ‘Aţudaddaula (r. 388/949–372/983) and entitled *Kâmîl aṣ-ṣinâ‘a at-ţibbiya or al-Kunnâs al-malakî*. This work, the Latin version of which bore a title, *Liber pantegni*, made up to sound

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46 Wiesbaden 1964.
48 ibid, p. 2.
49 H. Schipperges, *Die Assimilation... op. cit. p. 9.*
Greek, was described by K. Sudhoff as a work conceived like “cast from a mould… with such integral order and logical consistency, the like of which was not known in Greek medicine at all.”

In 1127, exactly 40 years after Constantinus’ death, Stephanus of Antioch translated the book into Latin a second time, but now under the name of its true author, ‘Al¬ b. al-‘Abb®s (Liber completus artis medicinæ, qui dicitur regalis dispositio hali filii abbas…). This clearly contradicted the statement by Constantinus, who had introduced himself as the author of the book: “He, Constantine, inspired by the great benefit of this science, had at first examined various Latin works and found them inapt for teaching. Thereupon he had taken recourse to the old Greek authors Hippocrates and Galenos, and of the more recent ones to Oribasius (of Byzantium), Alexander (of Tralles) and Paulus (of Ægina). He did not want to imitate Hippocrates, the excellent sovereign of the art, alone, as he found him often obscure and brief. Galen had written many extensive works… yet by their sheer magnitude discouraged many and consequently sixteen of his works were commonly used at most.” After Stephanus of Antioch, the second translator of the book, had accused Constantinus of plagiarism, his standing as an author was still is judged on widely differing terms. He was despised as a “plagiarist”, praised as a “magister orientis et occidentis novusque effulgens Hippocrates” and disparaged as a “mad monk”. Finally, around the middle of the 19th century, a French historian of medicine finally demanded “that a congress of European scholars may erect a statue of Constantine at the gulf of Salerno or on the height of Monte-Cassino.” In Julius Hirschberg’s opinion, Constantine “the Arabic renegade and later monk of Monte Cassino was not yet languishing under the concept of intellectual property.” On the other hand, he was praised by Karl Sudhoff: “Constantine loosened Salerno’s tongue. Under his influence, stimulated by his gifts, it now created its own literature, the first in the Western Middle Ages in the field of medicine. And even if one has to cancel out many excessively laudatory phrases about him by another member of his order, Petrus Diaconus, yet one fact is undisputed: he became the preceptor of the medical West, the ‘Magister Occidentis!’” Sudhoff knew that Constantine brought into circulation various other Arabic medical books under his own name and he justifies this process thus: “no author’s name is given in the case of purely Eastern writers to whom a number of minor works, such as a book on coitus, one on melancholy, one on forgetfulness and one on elephantiasis might belong as

well, where only his [Constantine’s] own name is mentioned as in the case of ‘Viaticus’ and ‘Pantegni’, which unjustly carry his name even though they are merely translations from the Arabic. Presumably he was hoping they would be accepted more readily by the scholarly circles of Salerno without the name of a Muslim author.”

Against this reasoning by Sudhoff the objection can be raised that Constantine also presented the Latin version of the ophthalmology book (Kitāb ‘Aṣr maqālāt) by Ḥunain b. Ishāq40 (194/809–260/873) as his own work to his readers. The latter was however not a Muslim but Christian and Constantine could thus have mentioned his name and religion with pride. Yet his preface to this book reads in translation: “Those words that we have explained sufficiently in the books ‘Pantegni’ and ‘Viaticus’ about the eyes are all that was available in the Latin language, because at the time we did not yet know the present small volume [93] dealing with the eyes. And therefore I, Constantine, monk of Monte Cassino, have compiled this booklet for you, Johannes, in order that you may find [more]—if you find the teachings of those books insufficient—whatever you may want to learn about the causes of ophthalmology, i.e. about the nature of the eyes and their composition.”61

It is surprising that Constantine on the one hand mentions the ‘small volume’ he used, thus giving himself away, yet on the other hand professes unambiguously to be its author. At any rate, this book on ophthalmology was considered his own achievement for more than 800 years until in 1903 J. Hirschberg was able to prove that it is in fact a translation of Ḥunain b. Ishāq’s book. This is all the more surprising because—as Hirschberg also has pointed out—Ḥunain’s work circulated in the West for centuries in another Latin translation, this time as a work by Galen and with the name of one Demetrio as translator. Constantine’s book “corresponds, however, most exactly with the so-called Galeni de oculis liber a Demetrio translatus. It contains neither one sentence more nor less, it has the same sequence of topics—it merely has a different division of the chapters and it concludes earlier than the latter, because the last section (the tenth maqāla) on eye ointments is missing.”62

In order to shed light on the question of how Constantine dealt with his Arabic sources his De melancholia shall be mentioned as another example. That book, printed in 1536 as a work by Rufus (of Ephesos), in the manuscript tradition is attributed to Constantine, following his statement in the book’s incipit: “I, Constantine, compiled this little book from many works of our most experienced doctors in that field, gathering excerpts of all that seemed excellent to me. We see that the celebrated physician Rufus has written a book on melancholy and in its first part said much about the symptoms of people with a melancholy disposition. This book is about the hypochondriac type of melancholy, but Rufus also touched upon and knew the other two types.”63

This incipit can serve as an instructive example of Constantine’s treatment of his Arabic sources. He replaced the name of the true author with his own, as shown by comparison with the incipit of the original.64 Even if we gather more

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61 Translated from Der ‘Liber de oculis’ des Constantinus Africanus. Übersetzung und Kommentar by Dominique Haefeli-Till, Zurich 1977, p. 22.
64 “This little book on the disease known as melancholy, viz. the sullen depression, was written by the physician Ishāq b. ‘Imrān as a memory aid for himself (in case of an eventual loss of memory, particularly approaching old age, which Plato used to call the mother of forgetful-
examples from Constantine’s works, the picture we get remains the same. They are very free translations with arbitrary [94] omissions, doing away with the names of Arab doctors, particularly those of the real authors. Latin texts of this kind, written in 11th century Salerno were, in Schipperges’ terms, the result of a “first wave of reception” [65] in the field of medicine. In his view “the elements of rational structure reveal a systematic organisation of the corpus.” [66] In this respect I come to a different conclusion. The original writings of the corpus consisted of works commonly known in western North Africa. Constantine’s selection was not by design but arbitrary. He took what he could collect without great effort, brought the Arabic writings to Salerno and made them, as far as possible, accessible in Latin with the help of the members of his order. No purposeful systematic work can be expected of him.

As far as Constantine’s influence is concerned, Schipperges argues that he had “no strategic impact” on Western medicine. “It only had a preliminary influence on European schools in general, however important the Corpus Constantinum was to become for Salerno.” [67] With this assessment Schipperges is right in so far as he compares this first wave of reception of medical works with the second wave coming via the Iberian peninsula. Yet the bearing of this ‘preliminary’ influence should not be underestimated. Especially as, with one single exception, these translations of more than twenty works were never replaced by better ones but remained in circulation as works by Constantine for centuries.

As far as Constantine’s treatment of his models is concerned, Schipperges avoids calling him a plagiarist. He holds that for Constantine’s achievement the common term of reception was unsuitable. It was, right from the beginning, rather a revision of foreign learning to a certain coherent end, viz. an intentional fusion (of the interpretation of doctrines for a wider public) and adaptation. For this, so Schipperges, the term assimilation should be used. [68] I, however, do not believe that the terms Schipperges suggests are apt to the way Constantine treats his originals. In my opinion, the latter’s translations are nothing but a form of reception. Certainly Constantine’s omission of the real authors of the works he translated was under no circumstances justified. It should be asked why he acted like this. In 1930 Hermann Lehmann [69] remarked in this context: “I do not see any other explanation but that he intended to exalt his standing in the university of Salerno.” I would tend towards a more differentiated explanation according to which Constantine’s plagiaristic treatment of his originals goes back to more than one factor: 1. The 13th century report on Constantine’s decision to bring Arabic medical books to Salerno appears significant to me. It relates how Constantine asked a physician in Salerno whether they were “sufficiently equipped with medical literature in the Latin language, which could not be affirmed. One had acquired knowl-

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65 Die Assimilation der arabischen Medizin, op. cit. p. 50.
66 ibid, p. 53.
67 ibid, pp. 53–54.
68 ibid, p. 52.
edge through practical application of ‘studio et exercitio’ and used them."

“From that Constantine had understood his cultural mission, returned to Carthage… and again applied himself to medicine for three [95] years, also collecting plenty of Arabic medical textbooks,… had then embarked… was overtaken by a storm… which badly damaged his manuscript treasures… With the remainder of it he luckily reached Salerno in the end.”

The crucial point in this report appears to be that the medical pursuits of the monks in the monastery of Monte Cassino, above Salerno, who were joined by Constantine, are said to have been of a practical nature only and that the monks had little or no literary experience at least in the field of medicine. Consequently they could not be expected to be concerned by the uncertainty created by Constantine in the question of authorship of the books translated from the Arabic.

2. Constantine was far superior to the other members of his order in his knowledge of languages, comprehension of the subject and also in literary ability. The monks presumably treated him like a prince and he decided freely and without interference on questions of authorship.

3. That he conceals the names of Arab authors of the translated works and of Arabic sources cited therein in favour of the Greek elements seems to have had religious motives.

Schipperges sees the beginning of the second phase of reception of Arabic medicine in the first half of the 12th century in Toledo which had under Arab rule from 711 to 1085. Not without influences through sporadic translations of Arabic books into Latin which had already begun in the 10th century on the Iberian peninsula, an intensive “reception of the Arabic Aristotle” started in Toledo. The city not only offered a wealth of written documents of Arab–Islamic learning to the Christian conquerors but also “the suitable climate for extensive cultural exchange because of its linguistic and cultural disposition.”

Schipperges calls the peripatetic encyclopaedia that reached the West with this wave of reception the ‘new Aristotle’. It was the Kitāb aṣ-Ṣifā of Abū ‘Ali Ibn Sinā (Avicenna, 980–1037), a revision of the Aristotelian Corpus.

Schipperges considers an advanced stage of the translation process in Toledo as a third wave of reception of Arabic medicine in the West. It took place in the second half of the 12th century; its most eminent translator was Gerard of Cremona (ca. 1114–1187). Amongst the works of Abū Bakr ar-Rāzī (Rhazes, 865–925) he translated the books al-Kitāb al-Mansūrī fi t-ṭibb (Liber medicinalis ad Almansorem), Kitāb at-Taqsīm (Liber divisionis) and Kitāb al-Ṣadar wa-l-Ωa◊ba (De variolis et morbillis). “With this body of writings, a solid foundation was laid for pathology and therapy. The awe inspiring last work of Rhazes, al-Ḥāwi or Continens was not translated until a century later by Farağ ben Sālim” and remained incomplete.

[96] Of greatest importance for the process of reception of Arab medicine in Toledo was the translation, also by Gerard of Cremona, of the Kitāb al-Qānūn fi t-ṭibb (Liber canonis de medicina) by Abū ‘Ali Ibn Sinā, which became the ultimate “codex of basic rules for a scientific medicine, including in the West”.

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71 A number of recent studies on Constantinus Africanus were edited by Charles Burnett and Danielle Jacquart, Constantine the African and ‘Ali ibn al-‘Abbās al-Maḡāsī. The Panteigni and related texts. Leiden etc. 1994.
72 H. Schipperges, Die Assimilation der arabischen Medizin, op. cit. p. 87.
73 ibid, pp 55 ff.
74 ibid, p. 56.
75 ibid, p. 56.
76 ibid, p. 58.
78 H. Schipperges, Die Assimilation der arabischen Medizin, op. cit. p. 93.
79 H. Schipperges, Die Assimilation der arabischen Medizin, op. cit. p. 93.
Mention should also be made here of the 30th chapter (on surgery) of the *at-Ta◊r¬f li-man ‘aghiza ‘an at-ta◊n¬f*, a comprehensive textbook of medicine by Abu l-Q®sim øalaf b. ‘Abb®s az-Zahr®w¬ (d. ca. 400/1010), also translated by Gerard of Cremona. This text, known in the West under the title *Chirurgia Albucasis* or *Tractatus de operatione manus*, has influenced surgery for centuries.

It should further be mentioned here that in the course of the Toledean vogue of medical translation, the “Introduction to Medicine” (*al-Mud¿al ila t-tibb or Mas¿’il fi t-tibb li-l-muta’allim¬n*) by Ḥunain b. Ishāq (809–973), which had already reached the West under the title *Ysagoge Iohannicii ad tegni Galieni* in translation by Constantinus Africanus, was brought into circulation again, as *Liber introductorius in medicinam*, by one Marcus of Toledo. This work was amongst the medical manuals with the widest dissemination in Europe and was “read at all universities until well into the 17th century”.

In the second part of his book, devoted to “people and centres of assimilation,” Schipperges attempts, at least regarding the 13th century, to shed light on the question as to what became of the Arabic books translated during the three waves of reception. “What role did those adopted and assimilated texts play in European medicine? In which ways and through what channels was the new learning incorporated into mediaeval therapeutics? Who were the exponents of these transfers, conflicts, codifications? What happened to these elements which, as Arabism in the wider sense, run through the late Middle Ages?”

In order to answer these questions, Schipperges focuses on the “centres of assimilation” in France, England and Southern Italy. In Chartres, which had come in contact with Arabic natural sciences from about the turn of the 10th century, the 12th century brought about the acquaintance with Aristotle (Arabus) and with Arab astronomy and medicine. After the re-conquest of the Spanish provinces, French schools started “the reception of Arabic learning from cultural centres under Arab influence. Early in the 12th century we encounter the first documents of a new scientific flourishing as a result of the contact with Arabic sciences in Southern France.”

Towards the middle of the 12th century a centre of translation emerged in Toulouse. It was based on the French tradition and soon formed a bridge to the centres of learning in Spain. The most important translators of the Toulouse school in the 12th century were Hermanus Dalmata and Robert of Chester. The books translated by them predominantly belong to the fields of astronomy, astrology and physics.

“The school of Toulouse gained further prominence at the beginning of the 13th century after the Parisian edict prohibiting Aristotle had been passed in 1215, when it became a warrant of a continuing Aristotelian tradition; philosophy and natural sciences enjoyed special attention in this school. Even though Pope Innocence IV extended the edict to the university of Toulouse in 1245 and Urban IV renewed it in 1263, these ordinances no longer had any practical effect”.

In the French centres of mediation, Jewish scholars played an important role by translating Arabic works into Hebrew and Latin. In connection with these scholars, Schipperges points out two facts which are significant for both the history of culture and the history of science. Firstly, the workshops of the translators were closely

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81 v. H. Schipperges, op. cit. p. 95.
86 ibid, pp. 111–118.
87 ibid, pp. 123–124.
88 ibid, p. 124.
89 ibid, pp. 126–127.
connected with the synagogues just like the madrasa to the mosque in Islamic culture, “a feature obviously in common with the Western institution of cathedral and monastery schools, and thus becoming a factor in the process of assimilation which must not be underestimated.”

Secondly, the tolerance practised towards the schools in the French region and the Jewish translators active there is surprising, particularly considering that in 1241 Christians could be excommunicated if they saw Jewish doctors for treatment.

In Paris, where in 1215 the study of Aristotle had been interdicted, the “new Aristotle” (Aristoteles Arabus) emerged victoriously from the middle of the 13th century in close association with the Latinised Ibn Sinâ (Avicenna). In this connection it is worth noting that “around the middle of the 13th century… the rationalistic enlightenment of Averroëan philosophy was already being officially fought and condemned.”

“Averroës, the epitome of all heresy in the Middle Ages, was not taken as a historical figure but as a weapon in the conflicting opinions of the 13th century. He was attributed with saying what nobody dared to express in any literary form, yet he also declared war indiscriminately against all extreme systems. Only the theological exponents of the 14th century tried to rectify pure Averroïsim. Through him, Paris became the place of encounter with Arabised antiquity in its most extreme form.”

“For the Parisian school Averroës was, in the 13th century, more of a personification of speculative endeavours in medicine and natural sciences, whilst in practical medicine Avicenna maintained his central position there as well.”

After his overview of the French schools, Schipperges moves on to the encounter of the English with Arabism: “Only one generation after Constantinus Africanus, a movement of scientific migration to the Arabised centres in southern Italy and Spain began in the Anglo-Saxon region which was to lead to a new and spontaneous wave of assimilation. Initially the subject was not medical science but the new mathematics and astronomy which, however, were to become very important for the foundation of the new perception of nature and thus also for the scientific foundations of medicine.”

“In the Spanish–Frankish region or in southern Italy, the Anglo-Saxon pioneers had a particularly vivid encounter [98] with the new science resulting in a broad and creative assimilation of the new material. After returning to their old schools in England they realised how dusty those were. In the attempt to break open the crusts, the new sciences became the timber from which the 13th century centres of learning in England were fashioned.”

The most important representative of this movement was Adelard of Bath [98] (active 1116–1142). After long sojourns in centres of assimilation in France, Spain, Italy and Syria, he returned to England. Through translations from Arabic into Latin he made some important astronomical–astrological and mathematical books accessible in Europe. He was possibly not only the

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90 H. Schipperges, Die Assimilation… op. cit. p. 128.
91 ibid, p. 128.
92 ibid, p. 129 ff.
93 ibid, p. 136.
94 ibid, pp. 137–138.
95 ibid, p. 138.
96 ibid, pp. 142 ff
97 ibid, p. 143.
99 v. Adelard of Bath. An English scientist and Arabist of the early twelfth century, ed. Charles Burnett, London 1987, including the following contributions: Margaret Gibson, Adelard of Bath; Alison Drew, The De edom et diverso; Dafydd Evans, Adelard on Falconry; Charles Burnett and Louise Cochrane, Adelard and the Mappae clavicula; Gillain Evans, A note on the Regule abaci; André Allard, L’époque d’Adelard et les chiffres arabes dans les manuscrits latins d’arithmétique; Richard Lorch, Some remarks on the Arabic–Latin Euclid; Menso Folkerts, Adelard’s version of Euclid’s Elements; Charles Burnett, Adelard, music and the quadrivium; Raymond Mercier, Astronomical tables in the twelfth century; Em-
As an important representative of the Anglo-Saxon assimilation movement in the second half of the 12th century we encounter Daniel of Morley. After a stay in Toledo, where he had belonged to the circle of disciples around Gerard of Cremona,\textsuperscript{105} he [99] returned home around 1177 with a large number of Arabic books. Whether he himself translated any of them we do not know. He exerted his influence in respect of Arabism more “through his personal communication”\textsuperscript{106} than with his less successful Liber de naturis inferiorum et superiorum.\textsuperscript{107}

Schipperges concludes his survey of the adoption of Arabic medicine in mediaeval Europe with a chapter on the currents of assimilation in Southern Italy. His valuable account draws a vivid picture of the situation in Sicily where, after the Arab conquest, “a natural link between the eastern and western cultures”\textsuperscript{108} existed between the 9th and the 11th century. There the process of assimilation assumed a new quality through the person of Emperor Frederick II (r. 1212–1250). The emperor was “oriented towards the Arabic world by personal inclination and private encounters.”\textsuperscript{109} We shall return to the question of the nature and fruitfulness of these encounters in another context. Here we shall mention only the names of those scholars who took part in the assimilation process as cited by Schipperges. The most important figure in the circle of scholars around Frederick II was Michael Scotus. This philosopher, alchemist, as-
troler and translator, who had been active in Toledo and Bologna, was called to Palermo by the Emperor.

To his “Sicilian period of translation Michael Scotus brought with him the spirit and the technique of the Spanish scientific tradition, particularly his proficient knowledge of the new Aristotle [Aristoteles Arabus], of medicine and music, of meteorology and alchemy.” We will have to pass over the works translated by him in Palermo, but I would like to draw attention to a tendency pointed out by Schipperges, viz. a body of corrupt translations using the name of Michael Scotus that betrays a sort of treatment of the sources that is detrimental to the history of science and that brought forth “innumerable unscientific and confused writings as part of the phenomenon of degeneration of manuscripts in the 14th and 15th centuries.” Thus a manuscript in Paris states that Michael Scotus translated Averroes from the Greek. An even more hideous example is furnished by “a 16th century manuscript which gives, following a fictitious Arabic text written in green, red and black, a Latin interpretation” One Michael Scotus of Prague reveals himself as the author of the purported Arabic text which under secreta naturae introduces a profusion of superstitious ideas into medicine. Of significance for the history of science here, as pointed out by Schipperges, is the tendency to integrate astrology and magic into medicine and to propagate this lore with reference to Arabic authorities—a tendency that can be traced back to the early 16th century.

Alluding once more to Heinrich Schipperges’ commendable study of the process of reception and assimilation of ‘Arabic’ medicine, we may conclude with a quotation from his summary: "If we approach [100] the entire period of reception in terms of intensity regarding reception currents we firstly find a group of initiators like Constantinus Africanus, Adelard of Bath, Dominicus Gundissalinus; followed by periods of incubation such as in Salerno and Chartres, continuing and protracted, also in southern Italy; after that a further group of promoting mediators like Petrus Venerabilis, Raymundus of Toledo, Frederick II of Sicily; and finally a group of realisators either flocking around figures like Gerard of Cremona, Michael Scotus and Hermanus Dalmata or gaining constitutional importance in characters like Wilhelm of Conches or Petrus Hispanus.”

“Regarding the assimilation movement we can distinguish: a period of pure of reception in which the material was acquired simply by registering it; such a period is discernible, however, only for mathematics and astronomy in the 10th and the 11th century; an imitative phase of reception in which the attempt was made to give an idea of Arabic science by means of compendia and compilations; a productive phase which, like in Chartres and Toledo, also interprets the new material creatively; and finally a critical–synthetic assimilation which got stuck in the attempts of the 13th and the 14th century.”

Let us now turn to geography and cartography, being the only other fields of Arab–Islamic sciences for which the issue of reception and assimilation has already been treated fairly comprehensively. First of all, it is remarkable that none of the classical works of the local anthropogeography—a matter in which the Arab–Islamic world reached an impressive level—came to the notice of European cosmographers. For a long time I have been pondering over the question as to why none of these works were translated into Latin. Was there, perhaps, no interest in the subject? Even if we leave aside the classical geographical works of the 4th/10th century, the question remains as to why in the West the impact of al-Idrisi’s geography, composed in Sicily, was limited to its maps. Should we not consider

110 G. Sarton, Introduction to the history of science, vol. 2, part 2, pp. 579–582
112 ibid, p. 175
113 ibid, p. 176
114 ibid, p. 187–188.
connecting the facts that the science of geography did not make any substantial progress in the West from the Middle Ages to the 16th century, and that the level of anthropogeography known from the Arab–Islamic area was reached only in the 19th century, with the fact that not a single Arabic textbook of this discipline was translated into Latin or indeed any other European language during either of the reception waves?

It seems that even those Arabic geographical works which, in translation, enjoyed a certain circulation on the Iberian peninsula, did not draw any attention in the neighbouring countries. This observation may be illustrated with an example. The geography of Andalusia by Abū Bakr Aḥmad b. Muḥammad b. Mūsā ar-Rāzī\(^\text{115}\) (274/887 – 344/955) was rendered into Portuguese on the commission of the Portuguese King Denis (1279–1325) after the oral translation of the Muslim Muḥammad (al-muʾallim Muḥammad) by a monk named Gil Peres, who did not know Arabic. From this were derived a Castilian version and several adaptations, also in Castilian.\(^\text{116}\) Even before its Portuguese translation, the book seems to have been well known in Spain. The anonymous author of the Historia or Chronica Pseudo-Isidoriana, who probably lived in the 12th century, took his description and the map of the Iberian peninsula from Aḥmad ar-Rāzī’s book, as we know today from a study by the French mediaevalist \(^\text{101}\) P. Gautier Dalché.\(^\text{117}\) Dalché is inclined to see this as a “strict case of influence of Arab on Latin culture,”\(^\text{118}\) but the influence seems to have been limited to the Iberian peninsula in this case.

The oldest Arabic geographical work of a descriptive nature known to have reached Europe so far is a description of Africa, published by Gian Battista Ramusio around 1550 under the title Della descrizione dell’Africa et delle cose notabili che ivi sono in the collection Navigationi et viaggi; it was written by the North African al-Ḥasan b. Muḥammad al-Wazzān, who had been captured by Italians and was later baptised Giovanni Leo (Africanus). We have already discussed (supra, p. 77f.) how profoundly this book influenced Italian scholars of the 16th and the 17th century, with its maps as well as its excellent descriptions.

It is further surprising that the text—as opposed to the maps—of the above mentioned work by al-Idrīsī only became known late and in the form of a heavily abridged and almost mutilated edition printed in Rome in 1592; it was translated into Italian by B. Baldi in 1600 and into Latin by the two Maronites Gabriel Sionita and John Hesronita in 1619.\(^\text{119}\) It is to be regretted that the Latin translation, without naming al-Idrīsī as the author, was erroneously brought in circulation as Geographia Nubiensis and was cited as such for a long time.

Even though Arabic anthropo–geography remained largely and for a long time unknown in Europe outside Spain, it seems established beyond doubt today that the mathematical geography and cartography of the Arab–Islamic world exerted a profound influence on their European successors from the 11th up to the 18th century.

As far as the mathematically oriented geography is concerned, we may say right away that the Ptolemaic geography, essentially consisting of a cartographic instruction manual and tables of coordinates comprising about 8000 localities, was not known in the Latin language area prior to the 15th century. Around the turn of the 13th to the 14th century, the Byzantine

\(^{115}\) v. C. Brockelmann, op. cit. vol. 1, p. 150, suppl. vol. 1, p. 231.


\(^{117}\) Notes sur la “Chronica Pseudo-Isidoriana,” in: Anuario de estudios medievales (Barcelona) 14/1984/13–32.

\(^{118}\) ibid, p. 14.

Maximos Planudes claims to have re-discov-
ered the Greek original which had been consid-
ered lost. It was translated into Latin at the be-

ginning of the 15th century by the Italian Jacopo
Angeli (Jacobus Angelus).  

The basic work of mathematical geography

TaΩd¬d nih®y®t al-am®kin li-ta◊ Ω¬Ω mas®f®t

al-mas®kin by

Abu r-RaiΩ®n al-B¬r'n¬ (d. 440/1048), unfortunately did not reach the West. The West did, however, sporadically receive glimpses of the notions longitude and latitude and how they were determined in the days be-

fore al-B¬r'n¬ as early as in the 10th century through contact with Arabic Spain. In the 11th
century this knowledge was deepened by the first translations of Arabic astronomical works in which those concepts and procedures occupy some room.  

As early as in the 10th century some latitude bearings appear on the discs of the astro-
labe attributed to Gerbert of Aurillac, later Pope Silvester II (d. 1003). [102] Three of the fig-

ures and lines inscribed refer to places in the Islamic world, the fourth latitude (42°) proba-
bly to Rome. This value too belonged to the lati-
titudes registered (as 41° 40’) on Arabic coordinate tables from the 9th century. Still, the works of Gerbert do not reveal any elements implying knowledge of mathematical geography.  

The oldest Latin work known to us that con-
tains an imitative adoption of an Arabic ta-

ble of the climata is De compositione astrola-
bii bearing the name of the Benedictine monk

Hermannus Contractus (Hermann of Reichenau, 1013–1054) as its author.  

In the first half of the 12th century in which the process of the reception of Arab–Islamic sci-

cences had progressed considerably, certain no-
tions, definitions, procedures and data of math-
ematical geography reached the West through the translations of several Arabic handbooks on astronomy. Between 1120 and 1130 Adelard of Bath translated the astronomical tables of Muhammad b. Mūsā al-Ḥwārizmi (active during the al-Ma’mūn period, 198/813–218/833) in the version of Abu l-Qāsim Maslama b. Ahmad al-Maqrīṣī (d. 398/1007). It was not least thanks to this that the use of the sine and of sine tables became known to the Latin world. What was even more important than this aid for a future work in mathematical geography was the four rules it contained for determining the latitude of any place. This also meant that the method first used by al-Ḥwārizmi to calculate the altitude of the pole, i.e. the geographical latitude, on the basis of the upper and the lower culmination height of a circumpolar star, came to be known.  

In passing, we may mention that the term algorithm and its derivations stem, in muti-

lated form, from the name of this mathematician and astronomer, al-Ḥwārizmi,  

Almost at the same time the Handbook of Astronomy by Muhammad b. Ġābir al-Battānī (d. 317/929) reached the West, at first in the translation by Plato of Tivoli and somewhat later, translated once more, by the above men-
tioned Robert of Chester (Robertus Ketenesis). From the point of view of mathematical geography the book not only has important implications for spherical trigonometry and rules for de-
termining degrees of latitude, but also contains a detailed table with geographical coordinates.  

From ca. 1130 onwards the oldest surviving handbook of Arabic astronomy, composed by Ahmad b. Muḥammad b. Ḥaqīr al-Fargānī (active between 218/833 and 247/861) reached the Latin world in the form of several different trans-

lations. Trough translations of this manual the West was presented with information more lucid than that of the two works mentioned above about the size of the Earth as deduced from the results of the measurement of one degree of the merid-

ian at 56½ miles, as commissioned by Caliph al-

120 v. F. Sezgin, op. cit. vol. 10, p. 272.
121 ibid, vol. 10, p. 205.
123 ibid, vol. 10, p. 209.
Ma’mûn, and knowledge of the division of the known world into seven climata. The book also provides a list of countries and towns which are arranged according to the seven climata, albeit without coordinates. Its profound influence in the 13th and 14th centuries on people like Robert Grosseteste, Albertus Magnus, Ristoro d’Arezzo and Dante Alighieri is well known. As late as 1464 Johannes Regiomontanus was still lecturing on al-Fârûqî’s book at the University of Padua.\(^{125}\)

Consequently, the first compiled geographical table appeared in Europe a few years after the first translations of the [103] Arabic manuals of astronomy mentioned above. It is one of several tables to be found in the *Liber cur- suum planetarum*, compiled from 1139 to 1140 by one Raymundo of Marseille. He omits the names of the translators of the works used by him and poses as the first translator of Arabic science.\(^{126}\) Although he mentions the names of a number of Arab and European authorities, he most probably did not consult their works. On the other hand, he regards himself as an emulator of az-Zarqâlî\(^{127}\) and even reports how in 1139 he was involved in a discussion with two scholars whose tables were faulty. For our particular subject it is worth noting that one of the tables in this book contains the coordinates of 60 cities taken exclusively from Arabic sources. The data registered here show that even at that early date tables of coordinates from several Arabic works had evidently found their way (via Spain) to Europe. The compiler was of course hardly in the position to realise that these coordinates are of a heterogeneous nature and that some longitudes were reckoned from different prime meridians. On the whole, however, it is to be regretted that even the earliest Latin compilation of Arabic astronomy was bound for plagiarism.

The earliest attempt made in the Latin world to add some European localities to an existing table of coordinates appears to have occurred towards the end of the 12th century. Such an endeavour can be observed in the *Theorica planetarum* attributed to the well known translator of Arabic works, Gerard of Cremona (d. 1187). In it the author appends the coordinates of European towns in France, Italy and Spain, derived without exception from Arabic sources. These coordinates however bear no relation to reality. According to them Paris lies approximately 4° east of Rome (it is actually 9°50' to the west) and 16' south of Toulouse (in fact 5°15' north).\(^{128}\)

In the 13th century, translations or adaptations of Arabic geographical tables and compilations based upon them, including descriptions of methods for taking coordinates, were so abundant that sooner or later attempts would be made to determine latitudes or longitudes in Europe outside Spain also. As far as we know, Ristoro d’Arezzo (d. after 1282) was the first Italian who, as a result of this development, aspired to calculate the latitude of a place astronomically. He determined the latitude of his hometown of Arezzo at 42°15', i.e. with an error of merely 1°13'.\(^{129}\)

The highest stage of assimilation of Arab–Islamic mathematical geography achieved in Europe at that time was reached by the Franciscan Roger Bacon (1214–1292). His is the only known early attempt made in his area to design a map based on latitudes and longitudes. It is illuminating to read his complaint that with regard to the Latin world there was still no knowledge of latitudes and longitudes; this, he adds, could not be attained, even by competent scholars, unless there was support from the Pope, king or emperor.\(^{130}\) Without purport-


\(^{128}\) F. Sezgin, op. cit. vol. 10, p. 212.

\(^{129}\) ibid, vol. 10, p. 225.

\(^{130}\) v. F. Sezgin, op. cit. vol. 10, p. 216.
ing to the reader that he had worked out the required latitudes and longitudes himself, he cites as his sources the Qānūn of astronomy (apparently az-Zarqālī’s book in Latin translation) and the “Tables of Latitudes and Longitudes” \[104\] (presumably the Toledan tables and their emulations). Apart from the fact that the coordinates of the sources at his disposal were in no way sufficient to compile a world map or even a regional map, they also diverged substantially from each other because they were based on different prime meridians.

In addition to the prime meridian 11° west of Toledo, Roger Bacon also knew the one located 28°30' west of Toledo, which he calls verum occidens, the “true west”; he preferred this alternative to the one at 29° used by other Andalusian astronomers.\[131\] Yet the reason he gives for this preference shows that he did not know that this shift of the zero meridian to 17°30' west of the Canary Islands was the consequence of a substantial correction of longitudes between Toledo and Baghdad that Arab astronomers and geographers had achieved in the early 5th/11th century, and by which the representation of the Mediterranean was reduced to almost its true length.

Despite the insufficient number of available coordinates, Roger Bacon allegedly designed a map and presented a copy of it to the then Pope. Some scholars take the view that this map, now lost, was confined to the northern hemisphere of the Earth in globular projection. The question, of course, is on what basis Bacon should have worked if he lacked longitudes and latitudes of the Latin world, as he complained. Could the limited number of heterogeneous coordinates known to him have sufficed, without knowledge of the coastlines, for the cartographic delineation even of the non-Latin world? Are we not much rather required to assume that he had recourse to a map from the Arab–Islamic world, perhaps even the world map of the Ma'mūn geographers, which did in fact use globular projection? In this connection we should not forget the primitive map by Bacon’s contemporary Albertus Magnus, which depicts only a few places in a crudely simplified, schematic form at odds with reality. We should also consider that a circular depiction of the surface of the Earth would have been in stark contrast to Roger Bacon’s concept of the shape of the Earth. For he believed, on the one hand—probably misunderstanding Averroës’s (Ibn Ruš’d’s) theory of the habitability of the southern hemisphere—that greater masses of water were present at both poles than in the centre of the Earth, where the waters extended from India in the east to Spain in the west; on the other hand, he leans on the notion of the existence of two places called Syene, one of which was said to be located in the Tropic of Cancer and the other on the Equator. Thus he arrived at the image of an Earth with two domes as depicted in his Opus maius:\[132\]

\[105\] The elementary procedures of mathematical geography as well as numeric figures which the West had received through multiple translations of al-Farāghānī’s Handbook of Astronomy


transpire in the works of Albertus Magnus (ca. 1200–1280). His *De cælo et mundo* shows that he was familiar with the measurement of the Earth commissioned by Caliph al-Ma’mân. He knows the result, viz. that one degree of the meridian equals 56 $\frac{2}{3}$ miles and he is also aware of the difference between the Arabic and the Latin mile. With him we also encounter the degrees of the northern and southern fringes of the seven climata as we know them from the Ma’mân geographers, from whom Albertus obviously took only full degrees, omitting the minutes.

It is also instructive that in *Speculum astronomiae*, ascribed to Albertus (or sometimes to Roger Bacon), the geographical longitude of Alexandria (51°20') is reduced in comparison to the value found in Ptolemy’s Geography (60°30’), which reduction was assumed to stem from Ptolemy’s *Canon*. It was, however, shown that this correction was indeed achieved only by the Ma’mân geographers.

From further details in the book, which overwhelmingly consists of a compilation of Arabic astrological and astronomical sources, it is evident that the author was familiar with the arc passing through Toledo as the zero meridian and with Arin as the starting point of the central meridian. At one point the author relates that he knows several astronomical tables, in which different cities such as Marseilles, London, Toulouse or Paris occur as prime meridians, stating that the latter two cities both have a longitude of 40°47’ and a latitude of 49°10’. This statement is not alone in conveying the impression that in the second half of the 13th century the West did not yet have a clear conception of longitudes or differences in the longitudes of important cities.

More obvious traces of the gradual adoption in the West of the basics of Arab mathematical geography are to be found in Dante Alighieri (1265–1321). Like his astronomy, his geography is also dependent on al-Fargānî’s *Handbook of Astronomy*, which Dante had not only been able to use in both Latin translations, but also in an Italian version based on a French translation. Al-Fargānî’s description of the seven climata was copied by Dante in every detail. Some longitudes and latitudes mentioned in the *Divine Comedy* are taken from Arab mathematical geography and show that here too he was dependent upon Arabic sources and that he was presumably using an Arabic map.

The surviving European coordinate tables create the impression that the interest in this matter grew continuously from the beginning of the 14th century and that the circle of those interested grew steadily in course of time. Examining approximately one hundred of these tables during my work on the volumes *Mathematical Geography and Cartography in Islam and their Continuation in the Occident*, I came to conclusions concerning their origin and character that I would like to quote here: Some of them are translations of Arabic originals, some are imitations of the *Toledan Tables* and some are extensions of the latter, when their time of origin dates back to before ca. 1250. From the last quarter of the 13th century onwards, the extension of the tables produced by Arab and Arab–Spanish predecessors was intensified, especially in Spain, with regard to European locations. Most of the extended versions were brought into circulation under the title of the *Alfonsine Tables*. From the beginning of the 14th century onwards, some of the tables produced in the eastern part of the Islamic world were translated into Greek by Byzantine scholars. These tables seem to have found their way to Europe from the beginning of the 15th century onwards. The compiling work commenced in Europe in the 15th century. On the one hand, this consisted of collecting

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134 ibid, vol. 10, p. 223.
135 ibid, vol. 10, p. 221.
136 ibid, vol. 10, p. 221–222.
137 ibid, vol. 10, p. 224.
138 ibid, vol. 10, p. 222.
place names and their coordinates from existing sources, and, on the other, of adding new coordinates of European towns and cities, regardless of what their origin might have been. It would seem that some of the compilers did not fail to use additionally available maps as sources. And so, while the piecing together of heterogeneous coordinates which had been gained at various times and on the basis of various prime meridians was indeed confusing enough, the translation of the Ptolemaic Geography added a new element of confusion from the first quarter of the 15th century on. Besides Italy, this was especially the case in Germany, where a group of scholars, such as Regiomontanus and further disciples of the Nuremberg School based their work for around half a century or even somewhat longer on the Ptolemaic coordinates.\textsuperscript{139}

With the Latin translation of Ptolemy’s Geography (1406) from the Greek and especially after it had first been printed (1477), not only was its wealth of material available in Europe, but new difficulties also arose. After all, coordinates had been adopted from Arabic tables which in some cases already contained corrected Ptolemaic data and which were partly also made up of newly-acquired values. This included the corrected length of the axis of the Mediterranean of 53\degree, a prime meridian which had been shifted westwards into the Atlantic by 17\degree 30', a different length of the Earth’s circumference from that of Ptolemy, and the related length of the meridian degree of 56 2/3 miles which was the valid figure among Arab geographers (in contrast to the 500 stadia of Poseidonios, which Ptolemy had adopted). All this made things difficult and confusing.\textsuperscript{140}

One of the consequences of taking recourse to the Ptolemaic Geography was that some of the geographers in Europe now returned to using the length of 500 stadia which Ptolemaios had assumed and Poseidonios had estimated, according to which one degree equalled 62 1/2 Roman miles rather than 56 2/3 miles, as the Ma’mün geographers had determined, a figure long known in Europe.\textsuperscript{141}

After the confusion over the measurements of longitude, which lasted around one hundred years, several attempts were undertaken to measure the length of a meridian degree. The first such attempt was made by Jean Fernel. Fernel, a medical physician by profession, prided himself on having measured the distance between Paris and Amiens in 1525 by the number of revolutions of the wheels of a stagecoach, thereby measuring the length of a degree at 100.602 kilometres and a circumference of the Earth at 39,817.00 kilometres. Despite a number of factors of uncertainty, the fact that he achieved such an astonishingly good result already made his successor Willebrord Snellius sceptical; he thought that Fernel had “merely arbitrarily converted the result of the Arabic arc measure into geometrical steps, but had fooled his contemporaries with an act of deception.” In reality, and despite this result, he stood “far \textsuperscript{107} behind the Arabs who had served as a model as far as the measurement of longitude was concerned”.\textsuperscript{142}

Amongst further attempts to measure the length of a degree of the meridian, the one by the said Dutch scholar Willebrord Snellius (1580–1626) stood out with its high scientific standard. His method involved a kind of triangulation. But due to imprecise measurements of the polar altitudes at his two localities (from which their latitudes were calculated), the figure for the Earth’s circumference he arrived at was too small.\textsuperscript{143} It is presently not known to me since when modern geography has possessed a value for the

\textsuperscript{139} F. Sezgin, op. cit. vol. 10, p. 230–231.

\textsuperscript{140} ibid, vol. 10, p. 270.

\textsuperscript{141} ibid, vol. 10, p. 280.


\textsuperscript{143} O. Peschel, op. cit., p. 396; F. Sezgin, op. cit. vol. 10, p. 382.
Earth’s circumference more precise than that of the Ma’mûn geographers.

During the period when under the influence of the first printed edition of Ptolemy’s Geography in Latin translation (1477) progress in the determination of longitudes and latitudes almost came to a halt in Germany and was completely interrupted in Italy, the geographical work (Taqwîm al-buldân) by Abûl-Fîdâ’ (d. 732/1331) with its comparative tables of coordinates was introduced in Europe. The French orientalist Guillaume Postel, who from 1534 had spent a number of years in the Islamic world as an envoy and missionary, brought a copy of the book from Istanbul to Paris. He translated the parts he considered useful for his Cosmographie compendium (Basle 1561) and used these to compile tables for the purpose of correcting the bearings of places contained in European maps and charts, and especially in Venetian ones. In 1554 he brought the tables to the attention of the above mentioned Italian scholar, Gian Battista Ramusio, who was the editor of Navigationi et viaggi and who passed them on to the cartographer Giacomo Gastaldi. Perhaps these two scholars already had a Latin translation of Abûl-Fîdâ’s book. Ramusio extracted a small selection of coordinates from it and expressed his delight about the discovery of the book with the words that it was “coming devinely to the light in our times.” The high reputation of the book soon spread across Europe and in the English scholar Richard Hakluyt (d. 1616) kindled the desire to make it known to a larger public in a printed edition. To this end he tried to procure a manuscript copy of it from Syria, home of Abûl-Fîdâ’, in 1583.

How well known Abûl-Fîdâ’s book was is also attested by the as yet inedited Volume of Great and Rich Discoveries by John Dee. It contains, inter alia, a report that around 1570 plans were in progress on whether one could reach Cape Tabin (Cape Chelyuskin) by sailing along the Arctic coast of Asia, i.e. whether East Asia could be reached by ship from the north. The two most eminent European cartographers of the time, Gerhard Mercator and Abraham Ortelius, disputed this while John Dee defended the theory of the navigability of that passage. He based his position on a detail from Abûl-Fîdâ’, viz. that northern China and the Asian coast were connected with Russia in the north and described this as “a record worthy to be printed in gold”.

Abûl-Fîdâ’s book was held in the highest esteem by the German scholar Wilhelm Schickard (1592–1635). This versatile scholar had been commissioned with surveying the duchy of Württemberg and he desired to collect data on geographical bearings in a much wider scope in order to create the prerequisites for the mathematical representation of a large part of the old oikoumene. He was well aware of the inadequacy of the contemporary methods for determining geographical longitudes. In his search for reliable geographical bearings, Schickard happened upon the Latin translation of the abridged version of the above-mentioned book by al-Idrîsî (supra p. 38), but found the book of little help for his purposes. After years of effort and correspondence, he received a manuscript of the Taqwîm al-buldân by Abûl-Fîdâ’ on loan from the collection of the Viennese orientalist Sebastian Tengnagel in 1631. Schickard began a Latin translation of the book with commentary, but the work was left incomplete due to his untimely death. During the last four years of his life he preoccupied himself intensively with the book; what he managed to achieve is a verbatim Latin translation with many lacunae, accompanying face to face on double pages the

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145 v. F. Sezgin, op. cit. vol. 11, p. 75 ff.
146 ibid, vol. 11, pp. 79–80.
147 ibid, vol. 11, p. 80.
148 ibid, vol. 11, pp. 82–83.
Arabic text copied by himself; supplemented by commentary in marginal notes.

Schickard’s attempts show that many significant Arabic sources on mathematical geography remained unknown to him as did the highly developed graticule of the old oikoumene created by Arab–Islamic geographers and astronomers from the turn of the 7th/13th century through the end of the 10th/16th century.149

Even in late 17th century Europe maps and tables of coordinates coexisted without any connection to each other. Thus Giambattista Riccioli (1598–1671), one of the well-known geographers of his time, commented upon his table containing about 2200 coordinates: “Almost innumerable are not only geographical world and regional maps but also the tables listing longitudes and latitudes of the more important places. However, they differ so greatly from one another, not only in the seconds, but often by whole degrees, so that this art seems to have lost all credibility, and one does not know whom to follow as the best guide in travelling across and describing the globe.”150

The last quarter of the 17th century marks the beginning of a new era in the measurement of longitudinal differences. Galileo had already discovered the satellites of Jupiter with his telescope in 1610, but only now did it become feasible to work out their immersions and emersions for common use. Thus in determining geographical longitudes, the observation of lunar eclipses could be replaced by that of Jupiter’s satellites. Credit for the ultimate success of this development is due to the astronomer Jean Dominique Cassini (1625–1712) in the context of the projects of the Academy of Sciences and its observatory founded in Paris by Louis XIV. At first the aim was a more accurate map of France, later the formidable task “of correcting the entire world map by proportional contraction or other revisions of the larger land masses.”155 One can easily imagine how difficult, costly and time-consuming the fulfillment of this task must have been even with regard to a small area of the Earth’s surface. The results of a research expedition with the aim of correcting the longitudes of the Mediterranean made between 1693 and 1696 by Jean Matthieu de Chazelles (1657–1710), a pupil and former [109] colleague of Cassini’s, were confined to the determination of the longitudes and latitudes of Cairo, Alexandria and Istanbul, and of the latitudes of Larnaka, Damiette and the Dardanelles.152 It was of course not to be expected that on the basis of coordinates gathered in such a way any substantial corrections of existing maps could be effected.

A comparison of the coordinates brought to Paris by Chazelles and the Arab–Islamic tables shows that, apart from the missing longitudes for Larnaka, Damiette and the Dardanelles, they are either almost identical or very close together.153 It is therefore remarkable that after this enterprise the members of the Parisian Academy expressed the view that their assumptions “about the true longitude of the Mediterranean had at last been confirmed by Chazelles’ measurements.”154 Of course they could not have known—as even today historiography of cartography still does not realize—that establishing the geographical coordinates of the Mediterranean region and further beyond took the joint efforts in the Arab–

149 v. F. Sezgin, op. cit. vol. 11, p. 84.
151 v. F. Sezgin, op. cit. vol. 11, p. 140.
153 v. F. Sezgin, op. cit. vol. 11, p. 144.
Islamic world over a period of centuries and that these data alone rendered the design up of accurate maps feasible.

Summarising my assessment—based on my own research—of the contribution made by European astronomers in correcting the mathematical basis of the traditional image of the world between 1690 and 1725 I have to say that this contribution was not greater and in this initial brief phase could not be greater than verifying a series of longitudes of prominent points on the world map on the basis of observations of the Moons of Jupiter. This made it possible to primarily assess the degree of accuracy of the west–east extension of important sections of the world map and to draw possible consequences for cartography. As far as we can tell today, longitudes of Arab–Islamic maps calculated from the zero meridian running 28°30′ west of Toledo prove to be several degrees too large. Thus the east coast of the Mediterranean is ca. 2°, Baghdad 3° to 3°30′, Derbent (on the western shore of the Caspian Sea) ca. 4°, Delhi ca. 4° and the east coast of China ca. 5°–7° too far east. A high degree of precision was achieved between Baghdad and India. In this case the deviation of Arab–Islamic maps from modern maps lies below 1°.155

When, towards the end of the 17th century, French astronomers and geographers aspired to correct or proportionately reduce the conventional maps on the basis of newly established longitudes and latitudes, Jean-Baptiste Bourguignon d’Anville (1697–1782), perhaps the most important of all French geographers, chose a different approach. He himself informs us about this in his Éclaircissements géographiques sur la carte de l’Inde (1753)156 on the cartography of the Indian subcontinent. To correct the map of India and verify its graticule and distances, d’Anville consulted the Arabic–Persian and Turkish works of geographical, historical and astronomical content that were known to him at that time. As far as we know he was the first European geographer of the 18th century who consulted and evaluated so many sources from the Arab–Islamic cultural sphere. The tables by Naṣiraddin at-Ṭūsī and Ulūg Beg did not escape his notice, their fame having spread in Europe since the edition and Latin translation by Johannes Gravius157 of 1652. Unfortunately, however, d’Anville considered only the latitudes and not the longitudes of these and other Arab–Islamic tables. This was probably because he was unaware of the fact that the prime meridian in some tables was 28°30′ west of Toledo or 17°30′ west of the Canary Islands and thus about 34°50′ west of Paris, rather than the 20° common with French cartographers since the last quarter of the 17th century. Consequently, the essential differences between the longitudes counted from the prime meridian passing through the Canary Islands and those counted from the newer prime meridian which had been shifted 28°30′ west of Toledo meant nothing to him either. He knew the former from the translation of the comparative table of Abu l-Fidā’. The Żiq-work of Ulūg Beg is misleading in this respect as the headline of the coordinate-table erroneously states that the longitudes were counted from the Canary Islands.158 As far as we are aware, it is James Rennell (1742–1830), who was the first European geographer to have recognised the great significance of the longitudes achieved by the “more modern” Arab–Islamic

158 We must consider this a slip. Roger Bacon already knew the prime meridian that had been shifted far to the west (supra p. 43); on the Ottoman side, I cite Muștafa b. ‘Ali ar-Rūmi (d. 979/1571) who in the preface to his table compiled in 930/1524 mentions the prime meridian shifted to the west (v. F. Sezgin, op. cit. vol. 10, p. 186).
scholars, at least for the regions between Aleppo and Delhi (infra, p. 111 ff.). Since d’Anville was unable to come to terms with the longitudes known to him, he based his work on distances given in the Arabic–Persian and Turkish works of geography and history, the book by Abu l-Fidā’ being his most frequently used Arabic source. Through this book which he used in translation, d’Anville obtained data from works which were not accessible to him in translations or which were not extant. He also made use of quotes by Abu l-Fidā’ from books not directly belonging to the field of mathematical geography but which covered areas of itinerary or topographical significance. It was indeed the works of Abu l-Fidā’ and al-Idrīsī which he was able to use almost exclusively in his treatment of the map of China.

D’Anville’s expectations regarding the accuracy of the latitudinal data contained in the “tables orientaux” and their validity for large expanses of the Earth surface, even beyond the Indian subcontinent, seem to have been rather high. Thus he comments on the position of the pronounced point Kambaya on the west coast of India as follows: “A translation which I possess from the book by Abu l-Fidā’ registers the latitude of Kambaya in accordance with al-Bīrūnī as 22°20’ which corresponds to the map but for an insignificant difference.” Incidentally, the name of al-Bīrūnī and his major work on astronomy, *al-Qānūn al-Mas‘ūdī* was to my knowledge first mentioned in Europe by d’Anville.

[111] After D’Anville, James Rennell, the eminent—perhaps the most eminent—English geographer, took up the task of verifying the cartographic depiction of the Indian subcontinent as known in Europe in the 1780s and aimed to improve it as far as possible on the basis of his own work. He took up work during his stay in eastern India in his capacity as Surveyor General of the British East India Company from 1763 to 1777. During the work on his project and especially in the course of the preparation of the accompanying text to the second edition of his map of India under the title *Memoir of a map of Hindoostan or the Mogul Empire* (London 1793) between 1783 and 1792, he came to realise the importance of local sources. Amongst his numerous Arabic, Persian and Turkish sources, the *Ā’īn-i Akbarī* by the great historian and geographer of the Mogul Empire, Abu l-Faḍl al-‘Allāmī (d. 1011/1602) assumes a pivotal position.

In his intention to depict India as realistically as possible on the basis of maps which had been produced over the past three hundred years, and to render the country interior as accurately as possible with the help of existing sectional maps and itineraries, the *Ā’īn-i Akbarī* was indisputably a source of the first order. It provided the most reliable means of verifying information pertaining to the eleven provinces above the Dekkan, because it not only provided extensive geographical descriptions and distances of routes, but also, and in particular, longitudes and latitudes.

Moreover, Rennell—like his predecessor d’Anville—also had the modern values for the longitudes of a small number of landmarks in India at his disposal. These had been determined by observation of the Jupiter satellites. When working on the map of India, he made the capital Delhi (not Greenwich) the starting point for further calculations of distance. Besides the *Ā’īn-i Akbarī*, he also relied on the tables of Naṣīr ad-Dīn at-Ṭūsī and Ulūg Beg, but he too erroneously believed that the longitudes in those tables had been calculated on the basis of a prime meridian which passed through the Canary islands, resulting in values that were more than 20° too great. Yet, since he calculated the longitudes backwards from Delhi, he became convinced that

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159 F. Sezgin, op. cit. vol. 10, p. 596.
160 ibid vol. 10, pp. 596–597.
161 ibid vol. 10, pp. 597-598.
they were sufficient for his purposes. For the evaluation of those longitudes from west to east, he found a way to reckon them by their differences from cities in the west rather than from a prime meridian.\footnote{v. F. Sezgin, op. cit. vol. 10, p. 608.} The manner in which Rennell based his design of the graticules for maps he revised on Arab–Islamic coordinate tables can be illustrated with an example: “Samarcand, according to the tables of Ulug Beig, is 99°16' east of the Fortunate Islands [the Canaries; as mentioned above, the shifted prime meridian 28°30' west of Toledo escaped him]; and Aleppo, in the same tables, is 72°10': that is, Samarcand is 27°6'E of Aleppo; and this last, being 37°09'E of Greenwich (by the latest determination of the French Academy, 34°49'E of Paris), Samarcand should be in 64°15' east of Greenwich. If we reckon it from Casbin (Qazw¬n), according to M. Beauchamp’s [Joseph Beauchamp, the astronomer 1752–1801] observation, is 49°33'E of Greenwich; and by Ulug Beig, 14°16' west of Samarcand; the latter, by this calculation, will be in 63°49': or 26 minutes farther west, than if reckoned from Aleppo. But having with much labour investigated the particulars of the distance between Casbin and Samarcand, and having compared them with the intermediate longitudes and latitudes recorded in the Oriental tables \footnote{J. Rennell, Memoir, op. cit. vol. 1, p. 199; F. Sezgin, op. cit. vol. 10, p. 609.} I am inclined to adopt 64°15', for the longitude of Samarcand. Its latitude, taken with the famous quadrant of Ulug Beig, is 39°37' and some odd seconds.”\footnote{J. Rennell, Memoir of a map of Hindoostan or the Mogul Empire, London 1793 (reprint: Islamic Geography, vol. 260), pp. 191–192; F. Sezgin, op. cit. vol. 10, p. 609.}

Rennell first tries to establish the longitude of Samarqand (99°16' in Ulug Beg’s table) as reckoned from Greenwich. Since he does not know the real prime meridian, he takes the longitude of Aleppo after Ulug Beg (72°10') and 37°09', as taken with the latest method of observing the Jupiter satellites. By adding the longitudinal difference of both cities after Ulug Beg to the longitude of Aleppo after the modern method, he obtains the longitude of Samarqand (99°16' – 72°10' + 37°09' = 64°15'). In a second approximation he proceeds likewise, using the longitudinal difference between Qazwin and Samarqand. If Rennell had known that the prime meridian on his Arabic–Persian tables was 28°30' west of Toledo (and thus 32°30' west of Greenwich) he could have calculated the longitude of Samarqand easily by the subtraction 99°16' – 32°30' = 66°46'.

Numerous other examples could be cited to show how Rennell, in revising the map of India and the territories to the north of it, in order to obtain as accurate coordinates as possible relied on the tables of Arab–Islamic astronomers and geographers, on the few bearings established by his European contemporaries and on distances given in parasangs or qoss (1 qoss = ca. 3 km) which he found in his sources. That the working material which he used were maps mostly based on originals from the Arab–Islamic world, shall be discussed later.

Finally I would like to quote Rennel’s own words regarding the importance of geographical tables from the Arab–Islamic culture sphere for European geographers of the 18th century in verifying the accuracy of available graduaded maps: “Had Ptolemy lived in the present times, he might have expressed his wonder, that, considering the advantages we possess, our maps of Asia should be so incorrect; when the tables of Abulfeda, Nasereddin, and Ulug Beig, and the History of Timur, by Sherefeddin, have been so long amongst us, in an European language.”\footnote{J. Rennell, Memoir, op. cit. vol. 1, p. 199; F. Sezgin, op. cit. vol. 10, p. 610.}

I now turn to the question of the influence that Arab–Islamic geography exerted on Occidental geography through its maps. To my knowledge, Joachim Lelewel, an historian of geography and also a capable Arabist, was the first to address the question of the origin of those maps which, from the turn of the 13th to the 14th century, de-
lineated the shape of the Mediterranean (often along with the Black Sea) almost perfectly. In Lelewel’s view, these maps, usually referred to as nautical charts and, in the course of time, also as portolan charts, were originally based on a graticule established by means of geographical coordinates, the same graticule that was also the basis of further developments. Lelewel assumes it was created by “the Sicilian geographers” (between 1139 and 1154) improving upon the material inherited from Arab geographers and their Greek predecessors in the form of al-Idrīsī’s geography and maps. The debates on the origin of the portolan charts which broke out afterwards, continue even today and views are often diametrically opposed to another. Arabists, independent of Lelewel, have occasionally expressed the view that these maps were derived from those of al-Idrīsī (1154 ce). Their efforts have however hardly been noticed by the vast majority of non-Arabist scholars. The reasons why this majority would not recognise or acknowledge the dependence of the maps on Arabic originals are many. Despite all efforts on the part of historical research in natural science to set this straight, a stubborn approach still persists to see the inherited knowledge of humankind only from an Eurocentric point of view. The clarity achieved by research in the history of science about the tremendous progress made by sciences in the Arabic-Islamic world—which, at the time when those almost perfect maps emerged, had already reached a very high stage in its development—was unfortunately neglected due to such preconceptions. It was a time that—in terms of history of science—falls in the period of reception and assimilation of Arab–Islamic sciences in Europe, when Europeans were acquiring new knowledge.

At first no significant evidence supporting the view that the so-called portolan charts were based on Arabic originals was at the disposal of Arabists. Moreover, hardly any attempt was made by Arabists to give an overview of Arab–Islamic cartography based on mathematical—astronomical principles and thus to instigate a discussion on its impact in the context of the process of reception and assimilation of Arab–Islamic science in the West. The motive for this passive attitude amongst Arabists was not so much the lack of convincing cartographic material but rather the notion which had imperceptibly become axiomatic in the West during the 19th and 20th century that the concrete cartographic representation of the Old World and its elaboration from the 13th century was a product of the western world and that it could not be otherwise. Like most of his contemporaries, the author of these lines was also conditioned by school and conventional wisdom in favour of this notion. When I consider it unjustified, historically unfounded and even absurd today, then I was led to this perception gradually and only in the last couple of years after long occupation with the subject; and in the beginning I had the good luck to happen upon the world map of the geographers of Caliph al-Ma’mūn (r. 198/813–218/833). The results of my research were published in 2000 under the title Mathematische Geographie und Kartographie im Islam und ihr Fortleben im Abendland as volumes 10 to 12 of the Geschichte des arabischen Schrifttums. Some of the reasons that caused me to revise the received notion, which I myself carried around for half a century too, I shall discuss here because they are relevant for the question of the reception of Arab–Islamic maps in the West.

According to present knowledge, the oldest map originating in Europe in which traces of Arab influence are recognisable was made

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by a Jewish apostate known by his Christian name Petrus Alphonsus. It is a schematic chart of the world included in a little astronomy book he wrote around 1110 CE. The map is southern-oriented as was the Arab custom and shows the Arabic division in seven climates and the name of the city of Aren (Arin).

[114] Clues pointing to an Arab influence can also be found in the famous world map by John of Wallingford (d. 1258).

One world map to which insufficient attention was paid by history of cartography appeared in the Livres dou Tresor (ca. 1265) by the Italian scholar Brunetto Latini, interestingly without any specific reference to the text. Its configuration, the delineation of oceans, mountains and rivers and the shape of the continents cause us to assume a model in the tradition of the world maps of the Ma’mün geographers and al-Idrísí, but already showing some further development regarding the shape of the Mediterranean, the Black Sea and Asia Minor. The image of the world as depicted in this map, preserved in Brunetto Latini’s work—as a whole and in detail—must have been perceived as entirely new and strange in the non-Spanish West, as can be shown by a comparison with all other surviving European world maps of the 13th century. A comparison of this map with the depiction of the oikoumene by Latini’s contemporary Albertus Magnus (d. 1280) or also in the world map of Petrus de Alliaco (1410), active in the 14th century, would alone suffice to show how unusual this depiction must have been for the West, leaving aside that the maps by Albertus Magnus and Petrus de Alliaco also betray traces of Arabic astronomical–cosmographical sources.

The second oldest world map known to us that displays a striking similarity with the Ma’mün and Idrisi maps dates from around 1320. It bears the names of Marino Sanuto and Petrus Vesconte as authors. In ignorance of the Ma’mün map, recent research has related this world map directly and solely to the al-Idrísí map.

The world map by Sanuto and Vesconte with all its versions is commonly grouped with the so-called portolan charts. The question of the latter’s origin has been debated since ca. 1850 and answered in various ways. We are of the opinion that these maps at their time represented the latest stage of development in the history of cartography, accomplished by humankind as a whole—a development which had been dominated for the past five hundred years by the Arab–Islamic world, and which was to be dominated by it for another three hundred years, viz. from around 800 until 1600 CE.

The reasons for my conviction that the remarkable accuracy of the coastlines and the longi-

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174 v. F. Sezgin, op. cit. vol. 12, map 55, p. 114.

tudinal proportions in the larger part of the so-called portolan charts was achieved during the Arab–Islamic period of the history of cartography shall be explained later, for the moment I would like to refer only to some of the indirect arguments presented in the first part of this introduction [115] (supra p. 50 ff.); right now I shall briefly introduce the three surviving maps, each of which marks an important stage in the development prior to 1300 CE.

First, the world map of the geographers of Caliph al-Ma’mün from the first quarter of the 3rd/9th century. A copy dated 740/1340 certainly fails to reproduce the original in all its splendour (infra III, 24), yet it and the map reconstructed after the surviving original coordinate tables (infra III, 25) show that this important work represents one of the defining stages in the universal history of cartography. The map is based on the one by Marinus (1st half of the 2nd century CE), on the Geography of Ptolemy (2nd half of the 2nd century CE) and on the results of the measurements and surveys made by a large group of scholars commissioned by the Caliph. It goes without saying that, in the first attempt at correcting and completing the inherited picture of the world, they were confined to gradual, if considerable, improvements. Their most striking contribution to the new world map consists in the following innovations which became pivotal for subsequent developments. Foremost, the Ma’mün geographers conceived the oikoumene as surrounded by water and Africa as circum-navigable in the South, as opposed to Marinus’s and Ptolemy’s assumption of one single, connected continent in which the Indian Ocean forms a land-locked sea. Moreover, the Ma’mün geographers reduced the excessive longitudinal extension of the Mediterranean in Ptolemy from 63° to 52° or 53° and made certain corrections in its cartographic depiction.

The next map, representing a further stage in the development, is the one by al-Idrisi dating from 549/1154 (infra III, 26ff). It is established today that al-Idrisi must have had the world map of the Ma’mün geographers as a model and not, as was often claimed, the one by Ptolemy (which most probably never existed). Despite certain drawbacks compared to the Ma’mün map, al-Idrisi’s world map shows a better delineation of the Mediterranean, of Europe, and particularly of Central, North and North-East Asia. These advances, made in the course of the roughly 325 years since the Ma’mün map, demonstrate that there was a lively development—especially regarding Asia—in the cartographic depiction of the Earth surface.

One of the surviving cartographic documents for the third stage of the development on the way to the so-called portolan charts is an Arabic–Maghribi map which depicts the coastlines of the western quarter of the Mediterranean with all the islands, the west coasts from Gibraltar up to northern France and parts of the English and Irish coast almost perfectly. With a passing reference to the Chinese world map, the one by Nasiraddin at-Tusi and the didactic scheme of the Mediterranean and the Black Sea by Qutbaddin as-Sirazi, all mentioned above (p. 49) and suited to support the notion sketched here regarding the stages of development of cartography in the Arab–Islamic world preceding the so-called portolan charts which appeared in Europe around 1300, we shall give some examples of the simultaneously created mathematical—astronomical basis for this development as well. In the first place, we shall consider the length of the great axis of the Mediterranean and the differences in longitude between some of its important coastal cities.

The values are taken from tables featuring the extensive corrections regarding the longitudes of cities between Toledo and Baghdad which had been made from the first half of the 5th/11th century. Thus the longitudinal differences between six cities according to the table of Abu l-Hasan al-Marrakušî\(^\text{180}\) (d. in or after ca. 660/1260 or ca. 680/1280) are as follows:

<table>
<thead>
<tr>
<th>City</th>
<th>Longitude</th>
<th>Modern Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangier L 24°10'</td>
<td>— Antioch 69°34'</td>
<td>45°23'</td>
</tr>
<tr>
<td>Tangier L 24°10'</td>
<td>— Rome L 43°00'</td>
<td>18°30'</td>
</tr>
<tr>
<td>Toledo L 28°00'</td>
<td>— Alexandria L 63°00'</td>
<td>35°00'</td>
</tr>
<tr>
<td>Toledo L 28°00'</td>
<td>— Constantinople L 60°00'</td>
<td>32°00'</td>
</tr>
<tr>
<td>Alexandria L 63°00'</td>
<td>— Antioch 69°34'</td>
<td>06°45'</td>
</tr>
</tbody>
</table>

The length of the Mediterranean between Tangier and Antioch, still at 45°23' in Abu l-Hasan al-Marrakušî, appears once more reduced and improved as 44°00'\(^\text{181}\) with his younger colleague Muḥammad b. Ibrāhīm Ibn ar-Raqqām\(^\text{182}\) (d. 715/1315). The resulting longitudinal differences are:

<table>
<thead>
<tr>
<th>City</th>
<th>Longitude</th>
<th>Modern Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangier 25°00'</td>
<td>— Antioch 69°04'</td>
<td>44°04'</td>
</tr>
<tr>
<td>Tangier 25°00'</td>
<td>— Rome 45°00'</td>
<td>20°00'</td>
</tr>
<tr>
<td>Toledo 28°00'</td>
<td>— Rome 45°00'</td>
<td>17°00'</td>
</tr>
<tr>
<td>Toledo 28°00'</td>
<td>— Alexandria 61°20'</td>
<td>33°20'</td>
</tr>
<tr>
<td>Alexandria 61°20'</td>
<td>— Antioch 69°04'</td>
<td>07°44'</td>
</tr>
</tbody>
</table>

The substantial reduction of geographical longitudes carried-out in the Arab–Islamic world reached Europe relatively early on, at least through the table by Ibn ar-Raqqām. This is included in an anonymous Latin text entitled *Latitudo et longitudo regionum sicut continetur in Libro alg'alien*\(^\text{183}\). Even though this manuscript may well date from the 14th century, neither that nor any other coordinate table found any use in European cartography for centuries. Wilhelm Schickard and Willem Janszoon Blaeu were the first in Europe to point out—as late as 1630—the distorted representation of the Mediterranean on maps,\(^\text{184}\) and it took until about 1700 before the length of the Mediterranean was established with tolerable accuracy.\(^\text{185}\) But how far removed Europe was from an exact mathematical representation of the Mediterranean, even in the second half of the 17th century, is illustrated by an overview of the divergent values recorded for the difference in longitude between Rome and Toledo which Michael Florentius van Langeren presented to the Spanish King

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\(^{181}\) ibid, vol. 10, pp. 166, 231.
\(^{182}\) ibid, vol. 10, p. 165.
\(^{183}\) MS Vienna, Nationalbibliothek 2452, cf. F. Sezgin, op. cit. vol. 10, p. 231.
\(^{184}\) F. Sezgin, op. cit. vol. 11, pp. 129,132.
\(^{185}\) ibid, vol. 11, p. 132 ff.
Philipp IV (d. 1665): Blaeu had assigned it 17°20', G. Mercator 20°, Ph. van Lansberge 21°, Tycho Brahe 21°30', Cl. Ptolemy 22°40' (for which read 26°40') and A. Maginus 29°40'. In reality it is 16°32'.

At this point the discussion of the depiction of the Mediterranean in Arab cartography as adopted in the West could be closed, if the unrealistic notions purported by historians of cartography were restricted to the origin of the so-called portolan charts of the Mediterranean. But such notions are also applied to a larger geographical area which is not believed to have been sailed by European mariners and the maps of which do not fall, strictly speaking, in the category of Mediterranean portolans. Thus one tacitly supports the common practice of not questioning the origins of maps of remote countries and entire continents such as Asia and Africa, or, should they be questioned, to assume they are original works by European cartographers who are supposed to have created them on the basis of information gathered by some sort of inquiries.

The map bearing the name of Giovanni da Carignano, who was the rector at the Marcus Church in Genoa and died in 1344, can serve as an interesting example. It is supposed to have been made around 1311 and comprises, besides the Mediterranean, the Black Sea, Europe and North Africa, Anatolia, Iraq and Persia with the Caspian Sea and Lake Urmia. This map, lost during World War II, was dealt with at length by Theobald Fischer in 1885. According to his opinion, the considerable part of the surface of the Earth depicted here was rendered quite accurately by Carignano in Genoa solely on the basis of 'inquiries'. Without repeating my criticism of his reasoning and motives, I content myself here with the concluding remark that most of Fischer’s finds regarding Carignano’s map actually point to at least one map representing more or less the latest development of Arab–Islamic cartography in the second half of the 7th/13th century that served as a model for Carignano. It may be expected that the shapes of the Caspian Sea and Lake Urmia in this original already reflected a further development of cartographic depiction than the state we know e.g. from the Idrisi map of 549/1154. Carignano might have used the Idrisi map as well, but his main model must have been a more recent map from the Arab–Islamic world in which cities were included that have been named only since the 6th/12th century by the Anatolian Seljuks.

A cartographic phenomenon to which in my view the historians of the subject did not pay adequate attention consists in the fact that one of the ‘portolan’ charts, viz. the one by Sanuto and Vesconte (infra III, 14), which dates from 1320 at the latest, already shows Africa with a circumnavigable shape, and that in another one from around 1351 the delineation of Africa shows signs of considerable improvement.

This attempt at correction becomes significant considering also the other parts of the cartographic work connected to it, known in modern literature as the Medici Atlas: this atlas also features a fairly realistic delineation of the Caspian Sea and the triangular shape of the Indian peninsula, besides some quite perfect regional maps of the Mediterranean and the Black Sea.

As far as I know, the Sinologist Walter Fuchs is the only scholar so far to have turned against the assumption that such a delineation of Africa

187 v. F. Sezgin, op. cit. vol. 12, p. 129.
190 ibid, vol. 10, p. 335.
192 ibid, vol. 12, maps 71 a–h, pp. 136-140.
193 ibid, vol. 10, p. 475.
194 ibid, vol. 10, p. 568.
in a European map could be due to the original achievements of a European map-maker. He came to this conclusion through his study of the Chinese world map from the turn of the 14th century which had been drawn on the basis of an image of the world dating from the end of the 13th century that had reached the eastern Mongol empire from the Islamic world and astonishes us with a depiction of the Mediterranean quite close to reality and the delineation of the triangular shape of South Africa. Fuchs emphasizes that it is hard to believe that such a depiction could have been a coincidence. He would tend to assume that the cartographic heritage of the Arabs had only been incompletely handed down and that those cartographers did not always reflect the current level of experience of their seafarers.

Unfortunately, it happens not infrequently that new elements appearing on European maps of the 14th century—regardless of what name the map may bear—are traced back to clues in Marco Polo’s travelogue, even if these are quite meagre or insignificant. I assume it is unnecessary to argue against the naïve view that it was possible to draw a tolerably realistic map of any part of the surface of the Earth on the basis of Marco Polo’s scattered, casual and often incorrect geographical information, or in fact of any observations made by travellers. The role played by Marco Polo or any other European Orient-traveller in the history of cartography can only have consisted in their bringing home cartographic material from foreign countries. Thus it is not surprising that Marco Polo, the Venetian businessman who visited on his outward journey the realm of the Ilkhans (1272) and on his homeward journey (1294/1295) several cultural centres of the eastern Islamic world such as Tabriz, where mathematical geography was cultivated in the 13th century, would encounter world maps and nautical charts of which he then saw to procure copies and sketches.

In the early 1930s, one map became known while four others followed in subsequent years, which Marco Polo is said to have had in his possession during his journey to Asia. They show roughly drawn coastal lines of South and East Asia, but also a remarkably accurate rendition of the Indian subcontinent and of the Malayan Archipelago. Of importance to us also are Arabic details and their Italian translations found on two maps surviving in a dilettante copy, one of which states that the map had been presented to Marco Polo in 1287 (erroneously 1267 in the manuscript) by a Syrian captain called Sirdumab (?), who sailed between Syria (Arabia) and the Far East for thirty years. I believe that these sketches represent the rudimentary outlines of some Arab–Persian world maps and nautical charts known to Marco Polo, the likes of which, in more developed formats and with greater detail, repeatedly found their way to European cartographers over the centuries.

In the course of the reception and revision of models from the Arab–Islamic area, countless non-graduated world maps were produced in Europe during the 14th and 15th centuries. Surely, not all of these maps were copied from originals, but frequently copies of copies and not free from the particular map–maker’s fancy. Only one of the most famous specimens shall be mentioned here, the map by Fra Mauro, a monk from the Camaldulensian (Benedictine) monastery on Murano off Venice, made between 1457 and 1459 upon the suggestion of the Portuguese

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197 ibid, vol. 10, pp. 315-316.
198 ibid, vol. 10, p. 316.
200 ibid, op. cit. vol. 10, p. 318.
King Alfonso V (1433–1481). In comparison the configurations of the map and its depiction of the three continents with the Mediterranean and the Black Sea turn out akin to the above-mentioned world maps by Brunetto Latini and Sanuto-Vesconte which in turn, as shown above, were based on Arab models. A new element compared to the two predecessors appears on Fra Mauro’s map in the fairly accurate shape of the Caspian Sea. It is to be noted that its north–south axis is rotated counter-clockwise by about 70°. In all probability this rotation is a consequence of fixing a regional map of the Caspian Sea into the world map forming the basis. It should also be mentioned that the map is southern-oriented as was the Arab custom and that more recent research pointed out the Arabic origin of the designation of the Atlantic in it: “Ocean of Darkness” (al-Bahr al-muẓlim). Moreover, it is stated in an inscription that an (Arab) vessel circumnavigated the South-African cape from the east and sailed into the Ocean of Darkness covering about 2000 miles in 40 days in unfavourable voyage. R. Hennig found that in this report “the most important fact from the point of cultural history is that Fra Mauro had no reservations referring to Africa as circumnavigable in the south, on the basis of those Arabic reports about sea voyages around 1420.” Moreover, a view circulated in the 16th century to the effect that Fra Mauro had compiled his world map on the basis of a “beautiful and very old world map and nautical chart” which Marco Polo and his father had brought from China. I understand that this would have been an Arab–Persian map acquired by the Polos in an Islamic country on their (supposed) return from China, whereby the actual model used by Fra Mauro does of course by no means necessarily stem from the Polos.

A certain degree of familiarity with the new image of the world created by Arab–Islamic geographers brought about an augmentation of knowledge in the field of mathematical geography in Europe, yet insecurity and confusion spread as well, caused by the edition of the Ptolemaic Geography in the Latin translation of around 1406, in print from 1477. The length of the Mediterranean—ca. 53° on the world map of the Ma’mūn geographers, the actual value being 42°—now appeared as 63° in the translated work of Ptolemy with its tables, and on the maps reconstructed according to those tables by the Byzantine Maximos Planudes around 1300 CE. The distance of India from the Canary Islands found on those maps was 125° (instead of 115° according to the Ma’mūn geography); Asia was connected in the south-east to Africa, the Indian Ocean thus turning into a land-locked sea; the Asian continent stretched in the east and north-east beyond 180°, the Caspian Sea spread about 23° from east to west in the shape of a melon, etc. Map-makers and cosmographers had the choice of whether they would stick to the version of the Ma’mūn geographers or would adopt that of Ptolemy. One of the key elements of the Arab-Islamic image of the world, namely that Africa is circumnavigable in the south and that the Indian Ocean is part of the ocean surrounding the oikoumene, did, however, prevail against the Ptolemaic view. A world-map which appeared around 1483–1488, shortly after the first edition of the Latin translation of Ptolemy’s Geography, is peculiar in combining the Arab–Islamic concept of an oikoumene surrounded by ocean with the Ptolemaic view of the Indian Ocean as a land-

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203 ibid, pp. 45, 49.
204 ibid, p. 54.
aligned sea. On the one hand it displays a rather good knowledge of Europe and a largely correct shape of the Caspian Sea, whilst on the other hand reflecting the Christian view that Paradise lies to the east of the oikoumene where the four main rivers of the Earth rise.\textsuperscript{207}

This ambivalence noticeable in European world maps since the introduction of Ptolemy’s \textit{Geography} could, however, not remain decisive for the new development which had begun in Europe in the 13th century. In fact, the Ptolemaic image of the world could not hold its ground for long, or to be precise, no longer than half a century, against the one found on the maps which reached Europe from the Arab–Islamic area mainly through Portuguese expeditions. Already with the first voyage of Vasco da Gama an almost perfect representation of Africa and of the western part of the Indian Ocean with the Indian peninsula reached the Iberian peninsula and Italy. This was followed by further maps, particularly an atlas with 26 regional maps written in Javanese script; the representation of the Indian Ocean in this atlas, \textit{inter alia}, testifies to the high level achieved in the cartographic survey of the Earth surface in the Arab–Islamic area before ca. 905/1500. The Portuguese seafarers in the Indian Ocean make no secret of having brought maps from there to Portugal and of having encountered advanced compasses and a highly sophisticated navigation amongst Arab seafarers. Moreover, Portuguese sources give detailed information to the effect that maps of the Indian Ocean with circumnavigable shapes of Africa got into Portuguese hands from the first half of the 15th century. This ultimately encouraged people in Portugal to head for India on the sea route which had long been known.\textsuperscript{208}

Around 1550, at a time when the regression in the depiction of the world map that had begun in Europe with the translation of Ptolemy’s \textit{Geography} still prevailed, the maps brought by the Portuguese began to make their impact. From the viewpoint of the history of cartography one can hardly overemphasize the importance of what we hear in this connection from Gian Battista Ramusio (1485–1557), a Venetian with a special interest in geography and travel accounts:\textsuperscript{209} “Since the representation of Africa and India on the maps in Ptolemy’s \textit{Geography} appeared very imperfect to me in view of the considerable knowledge about these regions which we nowadays have, I thought it expedient and not a little useful to collate the news from authors of our times who have travelled the parts of the Earth mentioned \textsuperscript{121} and treated them in detail and to illustrate them with nautical charts of the Portuguese, so that other such maps can be produced to the utmost satisfaction.” The maps reproduced by Ramusio comprise: 1) \textit{Africa}, 2) \textit{Arabia-Persia-India}, 3) the \textit{Isole Moluche} (Southeast Asia) and 4) a regional map of Africa. Besides the fact that all maps are south-oriented as was the Arab custom, their toponomy as well as the scales of longitudes and latitudes leave no doubt as to their Arabic origin.\textsuperscript{210} Yet, rather than the maps supplied by Ramusio himself, it was the map of Asia by a friend of Ramusio, Giacomo Gastaldi,\textsuperscript{211} that perplexed contemporary cartographers and still astonishes historians of cartography today. It appeared in the years 1559–1561 under the influence of Ramusio’s maps. How Gastaldi, an engineer from Venice, who had dedicated himself to the publication of Ptolemaic maps since 1539, suddenly came to prefer an entirely different representation of Asia remains an inexplicable phenomenon in the history of cartography to this day. His contemporary, the well-known cartographer Abraham Ortelius, who made his own version of Gastaldi’s map with a few minor

\begin{itemize}
  \item \textsuperscript{207} V. F. Sezgin, op. cit, vol. 11, p. 86.
  \item \textsuperscript{208} Ibid. vol. 11, pp. 358–362.
  \item \textsuperscript{209}\textit{Navigazioni et viaggi}, vol. 1, Venice 1563 (reprint: Amsterdam 1970), dedication, p. 2; F. Sezgin, op. cit. vol. 11, pp. 99–100.
  \item \textsuperscript{210} F. Sezgin, op. cit. vol. 11, pp. 100–103.
  \item \textsuperscript{211} Ibid, vol. 12, map 113b–d pp. 177–179.
\end{itemize}
changes, remarks in the bottom right-hand corner of his map of Asia.\footnote{F. Sezgin, op. cit. vol. 12, p. 182.} “[Herewith] we offer to the inclined reader a newer depiction of Asia which Jacobus Gastaldus, a man of great merit in the field of geography, [prepared] according to the tradition of the Arabian cosmographer Abu l-Fidā’i. Guillaume Postel, the famous mathematician who was also proficient in many languages, including Arabic, has brought this author from the Middle East to our Europe…”

I see the significance of this remark with regard to the history of geography in the fact that Ortelius obviously thought the appearance of a map of Asia like Gastaldi’s was possible only on the basis of the Arab tradition. Whether the coordinates in Abu l-Fidā’i’s book would have sufficed to design the configuration of a map or whether they were indeed congruent with Gastaldi’s map of Asia he certainly did not question. Neither could any one of his predecessors, contemporaries or successors in Europe have known that the geographical coordinates filed by Abu l-Fidā’i in a comparative table date from before the turn of the 13th to the 14th century and do not yet take into account the reduction of longitudes through the shift of the prime meridian to a position 28°30’ west of Toledo. After all, even Ortelius did not know that Gastaldi had for his part used one or several Arab maps as models which already complied with the prime meridian 28°30’ to the west of Toledo.\footnote{ibid, vol. 11, pp. 99–116.} The reaction of his contemporaries to the cartographic data provided by Gastaldi in his maps of Asia must have been tremendous; this can be recognised, \textit{inter alia}, from the fact that three years after the maps had been given pride of place on the wall of the Senate hall in Venice, extensive tables were compiled of the identifiable places with their coordinates.\footnote{ibid, vol. 11, p. 108.}

The most striking difference between the older (“Ptolemaic”) and the younger (“Arabic”) depiction of the Earth surface as applied by Gastaldi consists, in my opinion, in the fact that in the latter, Asia is no longer spread all over the map right to the edges in the north and the east as part of one continuous land mass, but has been assigned an oval, circumnavigable shape. This representation of the north-eastern edge of Asia after Arabic models which had already appeared sporadically in earlier European\footnote{ibid, op. cit. vol. 11, p. 119.} world maps, now gains general currency on contemporary and subsequent maps. This includes not only the circumnavigability of Asia in the northeast, but also its reduced size and its saddle-like shape, features not derived from the Ma’mūn map. In this respect the Idrisi map proves to be the oldest surviving model. Without repeating my explanation here,\footnote{ibid, vol. 11, pp. 108-109.} I may state that this important innovation dates back to the period before al-Idrīsī (549/1154) and continued to influence the development of the cartography of Asia in subsequent centuries.\footnote{ibid, vol. 11, p. 109.} In this connection we should also mention the dispute kindled around 1570 on the question whether Asia was circumnavigable in the north, which was denied by G. Mercator and A. Ortelius at that time.\footnote{ibid, vol. 11, pp. 104–107.}

Ortelius’s remarks in the bottom right-hand corner of his map of Asia and the question of the Arabian source of Gastaldi’s maps of Asia were repeatedly discussed in the 20th century. A convincing answer was not to be expected from the conventional opinion, that the portolan and world maps originated in Europe as long as the state of the cartographic–historic research did not permit consideration of an influence exerted by maps from the Arab–Islamic world. To make matters worse, there was almost no knowledge of the enormous development of mathematical geography in the Islamic world which could have provided the key to solving the entire com-
plex of the graticules on which European maps were based or with which they were supplied.\textsuperscript{219}

The importance of the innovations which Gastaldi introduced into the European cartography of the old oikoumene cannot be overestimated. Its greatest effect seems to have been caused by the maps of Asia by Abraham Ortelius and Gerhard Mercator. Ortelius gave the map of Asia a globular projection with some reduction in topographical errors. The extension of Asia between the eastern edge of the Mediterranean and the southern tip of India given on Gastaldi’s world map as ca. 47° or 48° was adopted almost unaltered by Ortelius for his globular projection. In Mercator the same section in stereographic projection is reduced to 44°.\textsuperscript{220}

Historians of geography have found various different ad-hoc explanations for the corrections on the graticules of the world maps which appeared subsequent to Gastaldi’s maps of Asia. Not wanting to repeat their views, I should rather like to give an account of the impression I gained during my study of mathematical geography and cartography in Islam and their continuation in the West.\textsuperscript{221}

Kepler had announced this map but did not live to produce it, hence it was drawn by his friend Ph. Eckebrecht, a citizen of Nuremberg, and published in 1630. The basic dimensions of the Old World such as the distances of the southern tip of India from the western edge of the Mediterranean, the longitude of the major axis of the Mediterranean and the distance between the east coast of Africa and the west coast of Sumatra at the Equator are similar, on this world map, to those on the maps of his predecessors Gastaldi, Ortelius and Mercator. His innovation to cartography lies in his treatment of the western basin of the Mediterranean.\textsuperscript{222}

Kepler left behind quite a heterogeneous geographical table of places in which he tried to harmonise Ptolemaic coordinates with those stemming from the first reduction of the length of the Mediterranean by 10°, effected by Arabic geographers. As a result we see that in his table and his map the eastern basin of the Mediterranean is about 10° too large—in compliance with the Ptolemaic figures, whereas the length of the western basin with the reduction by 10° is in accordance with the most advanced maps from the Arab-Islamic area and almost reaches the actual values. Fortunately, this distorted representation of the Mediterranean did not find any notable dissemination.\textsuperscript{223}

Subsequent to Gastaldi’s maps of the years 1559–1561 there was no substantial progress made in the development of the fundamental dimensions and the cartographic shape of prominent parts of the Old World, with the exception of the northern parts of Europe, until about the middle of the 17th century. Variations are restricted to decorative features or the mechanical shifting backwards and forwards of the African west coast in the graticule of the maps.\textsuperscript{224}

Only in the course of increased contacts of European scholars with the Islamic world, shortly

\textsuperscript{219} F. Sezgin, op. cit. vol. 11, p. 108.
\textsuperscript{220} ibid, vol. 11, p. 111.
\textsuperscript{221} ibid, vol. 11, p. 116.
\textsuperscript{222} ibid, vol. 11, pp. 121–122.
\textsuperscript{223} ibid, vol. 11, p. 124.
\textsuperscript{224} ibid, vol. 11, p. 117.
before the middle of the 17th century, did the European maps of Asia begin to attain a higher quality. Part of this consisted in the fact that it became more common to mention where the maps, brought from eastern countries or evaluated locally, had originated. In this respect the map of Persia brought back by Adam Olearius (1599–1671) figures, in my view, as a milestone. This scholar from Gottrop knew some Arabic and joined a trade delegation headed by Otto Brügmann travelling to Persia via Russia.

The journey lasted from 22nd October 1636 to 1st August 1639 and the description was published, together with the map, in 1647.\(^{225}\) The reaction of his colleagues at the University of Leipzig to the map was that he deviated “from the Opinions hitherto current among all Geographers.”\(^{226}\) They would not understand “wherefore he be at Variance with the world-famous ancient Geographers Ptolemy, Strabo, Dionysius Alexandrinus and others in the Delineations of the Persian Map, and especially of the Caspian Sea.”\(^{227}\)

Olearius’s account in his memories of the stay in Shamakhia (Š amāḥā), capital of Shirvan (Š arwān), is very instructive, not only regarding the origin of the map,\(^{228}\) but also for the general history of cartography. There he had the opportunity to become friends with an Arab astronomer and a theologian. The astronomer, who hailed from the Hejaz and called himself [\(\text{Hālīl (al-)}\text{-\text{Munāğgīm}, placed at his disposal the table of longitudes and latitudes “of almost the whole of Asia and also several Sections of detailed Maps which had been drawn.” Olearius adds that he had enclosed some of the maps in the edition of his book.\(^{229}\)]

He also relates that in order to occupy him, the leader of the expedition, O. Brügmann, asked him to combine the two “maps of Persia and Turkey in one”.\(^{230}\)

The limits of the sectional maps of Persia and eastern Turkey, which Olearius combined, transliterating their text into Latin letters, extend in longitude (on the northern edge) from 62° to 108° and in latitudes from about 23° to 48°. The prime meridian of the graticule lies 28°30’ west of Toledo. A comparison of the position of cities on the map with coordinates in the geographical tables which emerged subsequent to the foundation of the Maragha observatory in the sixties of the 7th/13th century, for instance with the table of Naṣiraddīn at-Tūsī (d. 672/1274), shows that both longitudes and latitudes match.\(^{231}\) Hence this map gives a good idea what an Arab-Islamic map from the period after the foundation of the Maragha observatory looked like and proves that they were graduated and very exact. Yet I believe that the map made accessible to the western world by Olearius represents a high, but not quite the highest stage reached in the cartographic depiction of this region in the Arab-Islamic world. It is however a great pity that this highly important document has so far not found adequate attention in the historiography of cartography.

The view of the Old World to which Europe was accustomed was supplied with new elements in the case of Asia by the French court cartographer and author of the first French world atlas, Nicolas Sanson d’Abbêville (1600–1667). If we disregard the map of Persia and eastern Anatolia introduced in Europe by Olearius, Sanson remains, to our knowledge the first European cartographer to express in all clarity that he took his map of Asia “from al-Idrīsī and other (Arab) authors” and that he had in part taken the


\(^{226}\) ibid, p. 204; F. Sezgin, op. cit. vol. 10, p. 398.

\(^{227}\) Olearius, Vermehrte newe Beschreibung, op. cit. preface, p. 8a; F. Sezgin, op. cit. vol. 10, p. 398.

\(^{228}\) F. Sezgin, op. cit. vol. 12, p. 211.

\(^{229}\) Olearius, Vermehrte newe Beschreibung, op. cit. p. 434.

\(^{230}\) ibid, p. 434; F. Sezgin, op. cit. vol. 10, p. 400.

representation of Tartary (Siberia) from maps which in turn had been produced on the basis of travel accounts and various Arab authors who had lived at that time. The map of Persia was a similar case.

To a still greater extent and more clearly than his regional maps, the various editions of Sanson’s maps of Asia and of the world yield an insight into how he kept improving his delineations on the basis of new models becoming available over the years. This impression is particularly striking when comparing his maps of Asia of 1650, 1651, 1654, 1659 and 1669.

The outstanding importance of the 1659 map consists, in my view, in the fact that it is the first European representation of Asia based on a graticule with the prime meridian at 28°30’ west of Toledo and taking into account the radical improvements in longitudes achieved in the Arab–Islamic area.

One of the new elements on this map of Asia in contrast to the previous one, drawn five years earlier, is the shape of the Red Sea with the Gulf of ‘Aqaba which had long since disappeared from European maps. The melon-shaped form of the Caspian, on an east–west alignment, which for more than a century one cartographer had copied from the other, gives way to an almost realistic representation of this same lake.

Three Siberian and Central Asian lakes, which may represent Lake Baikal, Lake Balkhash and Issyk-kul, appear for the first time together on a European map. Furthermore there is a new type of representation of mountains and rivers.

Not only geography-historical, but also toponomical and topographical considerations lead to the assumption that Sanson must have had an old map of Asia of Arab-Islamic origin as his model. Topographical and toponymical traces lead us to conclude that the original which Sanson used reflected a cartographic development in north-east Asia which may have taken place in the last half of the 5th/11th century. It is very likely that we are dealing here with Kımák Turks, who inhabited Siberia prior to the 6th/12th century. We find references to their work in al-Idrisi’s geography and maps.

With all due respect for the innovations introduced by Sanson into European geography with his major cartographic representations, I do not believe he possessed a reliable criterion for evaluating the longitudes and latitudes which became available to him as court cartographer. He probably made his selection according to the good reputation or the place of origin of a map whereby he benefited from the intuition of an experienced geographer. After Sanson it took only two decades until a breakthrough in the history of European cartography occurred, by establishing a direct connection between maps and the measurement of longitudes. Like the preceding decisive steps in the evolution of mathematical geography, this too enjoyed dedicated official support. It came from Louis XIV in the context of the Academy which he had founded, to which an observatory was also added. On the initiative of Jean Dominique Cassini (d. 1712), the observatory’s director, a new element for determining longitudes became effective in mathematical geography.

In the first phase, an attempt was made “to correct the entire world map by proportionate reduction or modification of the larger land masses.” Thus the astronomers created the Planisphère terrestre, a monumental world map on the floor of the west tower of the Paris Observatory. It was published in an improved reproduction by Cassini’s son Jacques in 1694 or 1696 as Planisphère terrestre suivant les nouvelles observations des astronomes.

A comparison of the coordinates of important localities of the Old World on this map and cor-
responding values in Arabic geographic tables with improved longitudes shows that, despite some deviations the Arab longitudes are more often correct than those of Cassini’s world map.\textsuperscript{238}

Then, towards the end of the 17th century, attempts were made in Paris to correct the world map with the aid of longitudes determined through observation of the Jupiter satellites by means of a telescope. It took a very long time to accomplish this task which has, perhaps, not even been completed yet today. Right from the initial phase of this project, but well into the 19th century and in individual cases even later, attempts at correcting the cartographic representation of the surface of the Earth by proportionate reduction of the longitudes of the inherited maps \textsuperscript{[126]} have not yielded any satisfying results, at least not applied to the latest models created in the Arab–Islamic world. Extant examples show that their longitudes, reckoned from the respective prime meridian, turned out 2° to 3° too large. Yet when longitudinal differences are compared with those on modern maps, e.g. the between Aleppo and Samarqand or between Baghdad and Delhi, they prove to be either almost correct or with deviations in the region of a few minutes. The attempts at correction remained, moreover, limited for quite a long time to the positions of prominent localities in the interior of countries or on the coasts. It also turned out that coastlines and the outlines of countries which had been established locally by the work of generations in most cases remained valid well into the 20th century. In this connection, it is illuminating to hear what the Sicilian Arabist M. Amari\textsuperscript{239} said around the middle of the 19th century about the state of affairs in the cartographic depiction of his home country. He had to realise that no map of Sicily existed in his day that “had been drawn on the basis of general triangulation” and that such a task requiring “merely time and money” had actually been started but then immediately abandoned again on several occasions.

For his attempt to draw an acceptable map of Sicily, Amari relied on the regional map of the island contained in al-Idrisi’s book, which had survived in a sole small-format copy, and on the configuration from the “least imprecise” map of his time into which he transferred the topographical features and the distances from al-Idrisi’s description.\textsuperscript{240} He determined the degree of precision of the data provided by al-Idrisi by comparing the sum of the distances recorded by the latter between the coastal points with the sum of the individual stretches of the coastline measured by the English captain W.H. Smyth between 1814 and 1824. When converted, this produced a largely concurrent result of 1050 km in al-Idrisi as against 1041 km in Smyth.\textsuperscript{241} It may be noted that the map of Sicily by Piri Re‘îs\textsuperscript{242}, which shows a more advanced depiction compared with Idrisi, was still unknown to Amari.

After the advances made by the astronomers of the Paris Observatory in modifying, as far as possible, the world map which had been checked at several points by reducing it some degrees in its longitude or by moving parts of the Old World westwards, the young member of the Paris Academy, Guillaume Delisle (1675–1726) took on the task of continuing the work, the results of which are referred to in the history of cartography as the “reform of cartography”. His achievement was however, like that of his predecessors and contemporaries, judged in complete ignorance of the vast preliminary work accomplished in the Arab–Islamic area. In the light of the Arab–Islamic maps and tables

\textsuperscript{238} v. F. Sezgin, vol. 11, pp. 141–143.
\textsuperscript{240} Regarding the map, v. F. Sezgin, op. cit. vol. 12, p. 26.
\textsuperscript{241} ibid, vol. 11, p. 35.
\textsuperscript{242} ibid, vol. 12, p. 88.
of coordinates known to me, I have pursued the question in how far Delisle must have been dependent on these maps. The case was limited to cartographic material of Persia, the Caspian Sea, the Caucasus, and the Aral Sea. Some of Delisle’s maps of these areas are remarkably accurate. Thus his map of Persia from the year 1724 provides a suitable example of how great his own contribution to this excellent representation may have been. Anyone who looks at this map more closely and compares it with the maps by Gastaldi and his successors or with the earlier Delisle maps will wonder how he was able to produce this map of Persia in the course of a few years. It impresses us with a topography expanded ten- to twentyfold, a more advanced hydrography, a much better representation of the Caspian Sea, the coastlines of the Persian Gulf and the Arabian Sea up to the borders in the north-west of the Indian subcontinent. Our astonishment grows when we see that the map of Persia fixes in its graticule the positions of about six hundred places, among them rather obscure places, villages, spas (hammâms), caravanserais, bridges, passes, fortresses etc., in such a way that their longitudes and latitudes—to the extent that these places still exist or have been included in a modern atlas—correspond, with minor deviations, to reality. Now the question arises as to how Delisle, from his Paris workshop, obtained the almost correct geographical positions of those hundreds of places and the coastal outlines on his map of Persia? It is not conceivable in any other way than that the map published in 1724 relied on a model reflecting the climax of a century-old cartography based on mathematical geography of the region in question. The maps of Persia emanating from the Islamic world which were made accessible in European languages by Giacomo Gastaldi (1559–61), Nicolas Sanson (1655) and Adam Olearius (1637) are not sufficient as the sole models of Delisle’s map. Despite unmistakeable common ground with earlier maps, the latter has an incomparably richer content and a greatly expanded graticule.

The best way to answer this question in my view is a comparison of the map’s graticule with the corresponding longitudes and latitudes of about fifty places in Arab–Persian tables whose prime meridian runs 28°30’ west of Toledo. The result of this comparison (which I presented in detail in my book a few years ago) convinced me that Delisle must have transferred en bloc the graticule of a local Persian map and its contents into his French edition without any proportionate shortening of the longitudes, let alone a change in latitudes. Hence his map can be considered a French translation of an Arab–Persian original which apparently represented the ultimate stage in the development of the cartographic depiction of Persia and the Caspian Sea at that time. In all probability the original dated from the 16th century.

This conclusion also applies to his maps of the Black Sea, of the Caspian Sea and of the Caucasus, for which I content myself with a reference to my above-mentioned book. However, in the case of the Black Sea map, I may add that Delisle himself incidentally pointed out that he had based this map exactly on a hand-written map highly respected in Constantinople, which [Jean-Baptiste] Fabre had brought to Paris. An Ottoman-Turkish copy of the map which had reached Paris and was used by Delisle as the model for his map of the Black Sea has, by happy coincidence, actually survived. The scales of longitudes and latitudes on this map prove that the delineation of the Black Sea had

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243 v. F. Sezgin, op. cit. vol. 11, pp. 149–150.
244 ibid, vol. 10, pp. 413–423.
reached a high \[128\] degree of precision under the Ottomans, and it turns out that the exact measurements of that Sea in degrees which Delisle had emphasised on his map are identical to the surviving Ottoman copy.\textsuperscript{250}

In the context of the endeavours to replace the outdated cartographic depictions of the Old World with more accurate maps emerging at the turn of the 17th to the 18th century, we may also mention the map of Persia by the Dutch Orientalist Adrian Reland (1676–1718). According to the words of his younger contemporary Chr. Gottlieb Jöcher\textsuperscript{251} (1694–1758), Reland had “made known various Maps of Persia, Palestine etc.” The title of his map of Persia,\textsuperscript{252} known so far reads in translation: \textsuperscript{253} “Delineation of the Persian Empire from the Writings of the Greatest Arab and Persian Geographers, undertaken by Adrian Reland.” Thus, according to his own account, Reland’s contribution must have been the Latin translation or transliteration—possibly with certain modifications—of a map that had become available to him in the original language. The map itself corroborates this assumption by being based on the graduation of the 13th –16th century Arab–Persian school of cartographers, whose prime meridian ran 28°30’ west of Toledo. However, compared to Delisle’s map of Persia, this map represents an earlier stage in the evolution of the cartographic depiction of this area.\textsuperscript{254}

In the group of cartographic depictions of parts of Asia which had thus become available in Europe and which had originated in the Arab–Islamic area, the map of Persia\textsuperscript{255} by J. Baptist Homann (1663–1724) offers an interesting ex-

\textsuperscript{250} F. Sezgin, op. cit. vol. 10, pp 448–449.


\textsuperscript{252} F. Sezgin, op. cit. vol. 12, p. 214.

\textsuperscript{253} In the original: Imperii persici delineatio ex scriptis potissimum geographicis arabum et persarum tentata ab Adriano Relando, cf. F. Sezgin, op. cit. vol. 10, p. 407.

\textsuperscript{254} F. Sezgin, op. cit. vol. 10, p. 407.

\textsuperscript{255} ibid, vol. 12, p. 216.

\textsuperscript{256} ibid, vol. 10, pp 407 ff.

\textsuperscript{257} ibid, vol. 12, p. 205.

\textsuperscript{258} ibid, vol. 10, p. 410-411.
42° that since 1700 had been achieved by the French astronomers.

The longitudinal differences between cities in Persia as they appear in Homann’s map betray a connection with the world map of the Ma’mün geographers as well. Contrary to my earlier assumption that Homann used the map by Olearius as his model for the map of Persia, I am increasingly induced to believe that the main model of Homann’s map must have been the map of Persia made available in Europe by the French scholar Jean-Baptiste Tavernier (1605–1689), who had travelled Turkey, Persia and India for about 40 years. The coordinates of 130 places which are registered in Tavernier’s Les six voyages en Turquie, en Perse et aux Indes show that he knew only the Ma’münian and post-Ma’münian coordinates reckoned from the Canary Islands and that the longitudes corrected by later Arab–Islamic scholars remained unknown to him.

Homann’s map of Persia—which, compared with those of Olearius and Reland, was generally speaking a regression, with only the Caspian Sea being given a conspicuously improved shape, probably through the mediation of Tavernier; yet Homann’s map must have acquired great fame very quickly, with the result that it was translated into Turkish within a few years and printed in Istanbul in this version in the year 1141/1729. My impression is that it forms the basis for the map enclosed in the ©ih®nnum® by º®™™¬ øal¬fa (1732) on the regions of Transoxania.

Two maps of northern Asia from the Arab–Islamic world reached Europe at approximately the same time as Homann’s map of Persia and were disseminated in French translation. One might call them the oldest maps of Siberia, but they actually cover Asia beyond Siberia to 25° in the south, and they contain the oldest virtually correct representations of the Black Sea, the Caspian Sea, the Aral Sea and the Transoxanian river system known to us. As part of the book

264 In his Memoir of a map of Hindoostan or the Mogul Empire, Second part, London 1793 (reprint: Islamic Geography vol. 261), p. 225, he writes in connection with a river in Guğarät (Gujerat): “I found the same name in a map of Persia drawn and engraved at Constantinople, in the year 1729” (see F. Sezgin, op. cit. vol. 10, p. 618).

265 F. Sezgin, op. cit. vol. 10, p. 412.
on the genealogy of the Turks by Abu l-Ğazi Bahadur Ḥân (b. 1012/1603, d. 1074/1663), both maps found their way from Turkestan to Tobolsk. There the book came to the notice of Philipp Johann Strahlenberg (b. 1676), a Swedish officer who was taken prisoner by the Russians in 1710 and deported to Siberia in 1711. He saw the book with a “Tatarian-Mahometan priest”, a cleric of the Siberian Tatars by the name of Agun Asbackewitz (Āḫund Özbekoğlu?), who had been given it by emissaries from Turkestan and “preserved among their documents”. Together with another prisoner known as Peter Schönström and with the assistance of the Tartar cleric, Strahlenberg saw to it that the book was translated, via Russian into German. The fame of the book must have spread so fast and so far in European geographical circles that the German translation was published in an anonymous French translation as early as in 1726, together with the maps prepared in a German version by Strahlenberg in 1715 and 1718. After his release from captivity, back home in Sweden, Strahlenberg published a foreword (Vorbericht) to the translation of the book by Abu l-Ğazi (1726), a book of his own entitled Das Nord- und Oestliche Theil von Europa und Asia (1730) and a map of Asia (1730). His comments on this German edition of the map are partly unclear, partly misleading, so that knowledge of the true state of affairs escapes the reader, giving the impression that Strahlenberg was talking of a map which he himself compiled during the first four or seven years (between 1711 and 1715 or 1718) of his captivity in Tobolsk.

The older one of the two maps is designated as the depiction of North Asia at the time of the Mongol invasion and in French translation bears the title: Carte de l’Asie Septentrionale Dans l’Estat où Elle s’est trouvée du temps de la grande Invasion des Tartares dans l’Asie Meridionale sous la Conduite de Zingis-Chan pour servir à l’Histoire Genealogique des Tatares. The title of the more recent map is as follows: Carte Nouvelle de l’Asie Septentrionale dressée Sur des Observations Authentiques et Toutes Nouvelles. Both maps are graduated and, predominantly by this feature, allow us to verify their Arab–Islamic origin and to obtain definite clues for their date of origin by comparing their graticules with geographical tables of cities. The comparison of coordinates provides us with irrefutable evidence that we are dealing with two of the most significant cartographic documents of the Arab–Islamic world. The results allow us to date the older map to the 7th/13th or the 8th/14th century and the more recent one to the second half of the 10th/16th century. With their coastlines, river systems and further topographic and toponymic elements besides their graticules, they corroborate our established view that the early development of the cartographic representation of North and Central Asia as reflected, relative to the Ma’mün geography, in the world and regional maps by al-Idrīsī, continued beyond this stage. In this later phase of development, we find that the positions of lakes and rivers flowing into the Arctic Ocean, which were placed somewhat roughly on Idrisi’s map, are now drawn in accordance with their true coordinates in our two maps. The representations of the two Asiatic land-locked seas, the Caspian and the Black Sea, have gained a remarkable precision compared with their configuration in al-Idrīsī’s world map. Those two important water basins, in their longitudes and latitudes and in their position relative to each other, now reach almost accurate dimensions in the graticule. They provide us with fur-

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267 F. Sezgin, op. cit. vol. 10, p. 379.
270 ibid, vol. 12, p. 173.
271 ibid, vol. 12, p. 201.
ther clues for tracing the Arab–Islamic basis of the graticules which have appeared in European maps since Ortelius and Mercator. Of these two maps, with which I have dealt at length in the context of the cartography of Asia, the older one, as a work of the 13th–14th centuries CE, completely agrees with the familiar development in the cartographic representation of the Mediterranean, of Africa with its insular shape, of South Asia and of the Indian Ocean and thus fills an essential gap, while the more recent one with all its progressive features emerges as an extremely important document of Arab–Islamic cartography from the second half of the 16th century CE.

I conclude these observations on the two maps of North and Central Asia with a remark on the cartographic representation of the Caspian region in the first half of the 18th century, penned by the great Russian Arabist W. Barthold (1869–1930), to whom we owe significant achievements in the field of the history of Arabic geography. Barthold describes the role of the Arab–Islamic area in the history of geography with deep respect and appreciation and continues: “Individual Arab maps were already being used by Europeans in the Middle Ages; some works by Arab geographers appeared in Latin translation as early as in the XVIIth century; despite this the detailed and accurate information of the Arabs on the Caspian and Aral Sea, the Oxus and Jaxartes had no influence on European science. What Western Europe could have learnt 800 years earlier from the Arabs was only learnt from the Russians in the XVIIIth century.

The correction of earlier ideas about the Oxus, the Jaxartes and the Caspian Sea is among the earliest findings of Russian research to be accepted by Western European science. In Remezov’s map of 1697, the Aral Sea (More Aralsko) is depicted for the first time as a landlocked sea completely separate from the Caspian, with the Aral Sea fed by the ‘Amun-Darya’ (Amu Darya, Oxus), the ‘Syrt’ (Syr Darya, Jaxartes) and several small rivers. More detailed information on the geographical situation in the area in question was collected in Russia at the beginning of the XVIIIth century and passed on to the French court geographer Delisle by Peter the Great, partly in person (during his stay in Paris in 1717), partly by letter. On Delisle’s 1723 map the Aral Sea is mentioned for the first time using this name, although the Greek Basilios Batatzes claimed that he had been the first to bring news of this inland sea to Europe in 1732, causing a sensation in London. At any rate, the maps of the XVIIIth century prove that people still had a very hazy notion of the geographical position of the area concerned and sought to rescue as much as possible from the Greek geographers’ assertions; Delisle even marks a river from the Aral Sea to the northern part of the Caspian as the ‘ancien cours de la rivière Sir’.

In two points of this thoughtful exposition, in particular, I have arrived at more differentiated views than Barthold, thanks to the more favourable situation today. The first point is that I am convinced that it was the maps of Arab geography rather than their descriptive passages which much more profoundly influenced the European map-makers, thereby ushering in a new epoch, and this influence was not restricted to work on the Caspian and the Aral Sea. The second point is that what had previously been regarded, in connection with the cartography of the Caspian or the Aral Sea; as the fruits of the research activity of Russian scholars in the first quarter of the 18th century can today be proven to be the rediscovery of the achievements of Arab–Islamic

270 F. Sezgin, op. cit. vol. 10, p. 396.
271 ibid, vol. 10, pp. 376-396.
geographers by the European, and among them, Russian cartographers of the 17th century. 

As regards the first point, it should be noted that, in the case of the Caspian Sea especially, the transmission of eastern influences to the West suffers from discontinuity and a lack of uniformity. Maps of Islamic origin deriving from different periods and representing different stages of development found their way to European cartographers. The latter, however, who were supposed to base their own maps on the models accessible to them, had no means of assessing their degree of accuracy. Thus the earlier, more accurate representation of the Caspian Sea seems to have been gradually consigned to oblivion from the early 16th century, i.e. after the dissemination of the printed version of Ptolemy’s Geography with its unrealistic depiction of the Caspian.  

The various maps brought to Europe in the 17th and 18th centuries by travelling scholars like Jean Chardin, Melchisédec Thévenot, Jean-Baptiste Tavernier, François Petit de la Croix senior and junior, François Bernier, Jean-Baptiste Faivre, William Kirkpatrick or James Rennell cannot be discussed individually here; hence I shall restrict myself to two examples that seem suitable for illustrating the attempts of European cartographers to make the best possible use of map material and coordinate tables which had become accessible to them.

The first example refers to the caption, mentioned above, on the Map of Turky, Little Tartary, and the Countries between the Euxine and Caspian Seas by the English cartographer Emanuel Bowen (after 1738). In it Bowen states that for his map assembled from various models, he made use, apart from the map of eastern Anatolia and Persia which had appeared in 1729 in Istanbul, of the following map materials, inter alia: the representation of the coast of the Black Sea from the Azov Straits up to the northern mouth of the Danube was taken from a Turkish map… the River Tigris and parts around Basra follow an Arab map which was appended to Thévenot’s collection of travelogues. In the case of the lakes Van and Urmia (Shahi), he states that he did not follow G. Delisle, whose map of Georgia he had used, in representing them as almost contiguous since the latter had “produced no authority for such a considerable alteration.” Bowen goes on to name a few more maps by European contemporaries to which he had recourse. In a second inscription he lists coordinates. They are latitudes for a number of places which he cites as the results of observations of older and younger contemporaries, or gleaned from Arabic tables like those of Ibn Yûnis, al-Battānī or Naṣīraddîn at-Ṭûsî. He omits the longitudes of the Arabic tables, except for one by al-Battānī. He probably did that because he could not cope with the different prime meridians of the Arabic tables.

The second example is about the well-known French geographer and cartographer Jean-Baptiste Bourguignon d’Anville (1697–1782) and how he dealt with an Ottoman-Turkish map of the Red Sea probably made between 945/1538 and 948/1541. According to his description, this map depicted the Red Sea from the north down to Jeddah (Gudda), and he used it in drawing the northern parts of the map Golfe Arabique ou Mer Rouge appended to his Mémoires sur l’Égypte ancienne et moderne. Noteworthy here is d’Anville’s hint that he had taken the representation of the Gulf of as-Suways (Suez) and

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275 F. Sezgin, op. cit. vol. 10, p. 345.
277 ibid, vol. 12, p. 226.
278 It is Relation de divers voyages curieux, qui n’ont point esté publiés et qu’on a traduits ou tirés des originaux des voyageurs français, espagnols, allemands, portugais, anglais, hollandais, persans, arabes et d’autres Orientaux, le tout enrichi de figures et de cartes géographiques, Paris 1663–1667.
279 F. Sezgin, op. cit. vol. 10, pp. 455–457.
the Gulf of ‘Aqaba from this Turkish map. He says that he owes to it, inter alia, the knowledge of a spit of land (which actually does not exist) projecting southwards into the Gulf of ‘Aqaba, splitting, as it were, the northern end of the gulf into “two gulfs of their own”. This means that d’Anville had, in the second half of the 18th century, still no means of judging from Paris to what extent the representation of the Gulfs of Suez and ‘Aqaba and the Sinai Peninsula were drawn correctly in this Ottoman map.\textsuperscript{282} Hence it should not surprise us that it took no less than half a century to correct this error in European cartography.\textsuperscript{283}

D’Anville and the Englishman James Rennell (1742–1830, supra p. 111 ff.), the two most illustrious geographers and cartographers of the 18th century, showed great respect and due appreciation for the achievements of their Arab–Islamic predecessors. Not only did they rely in their descriptive accounts regarding the maps of Asia and Africa to be revised with confidence on descriptions, geographical coordinates and other data concerning distances of their Arab–Islamic sources, they also consulted maps which had originated in the Arab–Islamic world and which they had become aware of in the course of their work. To quote sources and name models was not an established tradition, least of all in cartography. In this connection it is instructive that as late as 1755 the cartographer Robert de Vaugondy\textsuperscript{284} reproved an omission of this sort made earlier by his colleague d’Anville: “As far as the Asian [134] part of Turkey and the Persian Empire are concerned, we would like to know the originals which provide the basis of the new information supplied by M. d’Anville in the first part of his [map of] Asia: they contain details different from what can be expected from the accounts of a traveller. The topography which they represent can only have been taken from hand-drawn regional maps, after local measurements, and the knowledge of which would doubtless be very useful for us.”

\subsection*{Routes of Arab–Islamic Sciences into Europe}

The preceding part of this introduction dealt with the process of reception and assimilation of Arabic-Islamic sciences in the West, in particular in the fields of philosophy, astronomy, music, medicine and geography, starting from some existing studies on this matter which have the character of preliminary works or which seek to explain the process on the basis of certain literary documents, rather than the subjects. Here now the routes on which the process of reception and assimilation in the West began shall be discussed briefly.

1. The route via Muslim Spain

Surely the oldest and best known route is the one originating on the Iberian peninsula, which came under Arab rule almost completely within 20 years of the invasion of 711. The sciences pursued by the conquerors during the next one and a half centuries there were largely the same as those cultivated in the centre of the Islamic world.

At an earlier stage of the acquaintance with the subject was reached the view that the first encounter of the Christian West with Arab–Islamic science occurred in the last third of the 10th century through personal contacts between individuals from both areas in the Hispanic Marches around Barcelona. In this process, Gerbert of Aurillac (b. ca. 950, d. 1003), elected Pope Sylvester II in 999, was considered a forerunner.

In the case of the introduction of Arabic numerals into the Christian West which had been

\textsuperscript{282} F. Sezgin, op. cit. vol. 11, pp. 417–419.
\textsuperscript{283} ibid, vol. 11, p. 419.
\textsuperscript{284} Essai sur l’histoire de la géographie ou sur son origine, ses progrès et son état actuel, Paris 1755, p. 385; F. Sezgin, op. cit. vol. 10, p. 457.
connected with his name, new documents and references have meanwhile emerged that are not related to him. Thus Arabic numerals appear in two manuscripts, copied in the Hisppanic Marches in 976 and 992 CE respectively. These important documents preserved in the library of the Escorial have not yet been considered by the historians of mathematics. Moreover, in an extant letter by Gerbert we discover that he asked the abbot Gerald of Aurillac to obtain for him the treatise *De multiplicatione et divisione numerorum* by one Joseph Sapiens (or Hispanus), from which it becomes evident that the knowledge of Arabic numerals must have found its way to the south of France even before this time.

Moreover, an astrolabe from the 10th century is extant (infra II, 91), the Latin inscription of which turns out to be a transliteration of what were originally Arabic letters. Marcel Destombes, who discovered the astrolabe and owned it at the time, identified it as “Carolingian” on account of the type of script used and recognised an early acquaintance with Arabic numerals outside Arab Spain in the numbers on the back and on the disc which are expressed by the letters of the Latin alphabet. The quite perfect form of the astrolabe which, according to a note dates from 980, presupposes a certain amount of familiarity with the application and construction of the instrument, at least regarding a limited geographical area. Another surviving astrolabe (infra II, 94) is attributed to Gerbert himself, but is most probably not his work.

The extant treatises *De mensura astrolabii* or *De utilitatis astrolabii* and a *Geometria* bear Gerbert’s name. Their authenticity and their dependence on Arabic sources have not yet been explained in detail and with certainty. An in-depth study by Arabic studies is still due. In 1888 H. Weissenborn came to the conclusion that “the methods and instruments of measurement as described in the second part of the so-called Gerbert geometry originated with the Arabs.”

In his study of geodetic instruments (1912), J. Würschmidt came to the additional result “that the majority of the problems dealt with in Gerbert’s geometry were solved by contemporary Arab scholars in mostly the same form and with the same devices; the latter discussed a number of other, more complicated problems, while the Gerbert geometry only compiled those problems which can be solved with the most basic methods and in the shortest time.”

The astrolabe treatise betrays its Arabic origin quite clearly. It was however not a direct Latin translation of an Arabic original, but seems to have been based indirectly on another Latin text which presumably for its part was a translation of an Arabic work on the astrolabe. Even

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though its table of the seven climata with the corresponding place names is an element alien to Arabic astrolabe treatises, the very contents of this table—which cannot be explained without the knowledge of an Arabic source—indeed reveal a connection with the world map of the Ma’mûn geographers. However, we cannot judge whether the author of the Latin astrolabe treatise inserted the table himself, or whether the translator found it already included in the Arabic original and took it along with the text. Either way, this is but one of several clues to the Ma’mûn geography and its book of coordinates having reached the Iberian peninsula quite early on.

The early date of the Latin treatise on the astrolabe attributed to Gerbert can be explained more easily in the light of [136] a work on the astrolabe also written in Barcelona which was supposedly penned by a contemporary of Gerbert by the name of Lupitus, probably also a cleric. It is assumed that a copy of the little book by Lupitus was at the disposal of Gerbert or the author of the treatise which bears his name.

J. M. Millas Vallicrosa, who edited the treatise by Lupitus entitled Sententie astrolabii on the basis of six manuscript copies, still believed it was a direct Latin translation of an Arabic original. The true nature of this astrolabe treatise was revealed only fifteen years ago by Paul Kunitzsch in an article entitled al-Khwârizmî as a Source for the Sententie astrolabii. Kunitzsch compared the Latin monograph with the Arabic treatise on the astrolabe by Muhammad b. Mūsâ al-Ḥwârizmî (active under the Caliph al-Ma’mûn, r. 198/813–218/833). The comparison showed that of the three parts of the Sententie—a short introduction, a description of the astrolabe and a section on its use—the first part was apparently freely formulated by the Latin compiler, the second, by its terminology betrays a strong Arabic influence and the third section is one seventh a literal translation from al-Ḥwârizmî’s text and the rest made up of long explanations and comments by the Latin editor. Whether Lupitus dealt with his Arabic model in this way because he had problems with the literal translation, or because he wanted to be seen as an independent author of the booklet we cannot know. At any rate he did not conceal the Arabic origin of his knowledge, as he left many technical terms and names of stars which he adopted untranslated. Moreover, he inscribed the Arabic alphanumeric characters not in transcription but in Arabic script on the discs and on the back of the mater. Yet he did not mention the name of al-Ḥwârizmî, the author of his source.

This treatise which imparts the content of al-Ḥwârizmî’s treatise in a dishonest way exerted a profound influence on the astrolabe literature in Europe from the beginning of the 11th century to the 16th century, even though it was not the only treatise of its kind that made the contents of Arabic works on this subject available in Latin works. To all appearances Gerbert’s treatise was the first to draw on Arabic models. The question of whether Gerbert himself wrote it or one of his pupils or followers did is still open. How great the influence of the Sententie astrolabii was can be seen, above all, in the fact that an extensive body of anonymous Latin writing emerged as


294 Assaig d’història de les idees físiques i matemàtiques a la Catalunya medieval, vol. 1, Barcelona 1931 (=Estudis Universitaris Catalans, Serie monogràfica vol. 1), pp. 275–293.


297 P. Kunitzsch, al-Khwârizmî, op. cit. pp. 231–232

298 ibid, p. 233.
an offshoot of this book and is preserved into our time. The way to further adaptations and imitations outside Spain, in the North had thus already been paved in the first part of the 11th century.

The earliest known phenomenon in the imitative sense is a text entitled *De mensura astrolabii*. It bears the name of Hermannus Contractus, alias Hermann of Reichenau (1013–1054). Remarkable about this treatise is, inter alia, that its table of the seven climata and its listing the names of cities in an east–west order betrays a knowledge of the handbook of al-Fargānī even before it was translated into Latin. Hermannus is also supposed to have been the one who introduced the portable cylinder clock and the quadrant from Arabic Spain into Europe.

Even if the possibility cannot be ruled out that the authorship of Lupitus and Gerbert for the works mentioned above is spurious or very doubtful, they are still important documents of the early period of reception of Islamic sciences by the Latin world via the Iberian Peninsula, after the social and economic contacts between Arabic Spain and the adjacent countries had already begun in the early 8th century. A. van de Vyver gave an apt description of this process in 1931: “Ces adaptations latines de la fin du Xe siècle et du début du XIe, – anonymes, brèves et mal composée, – font l’effet de notes et de traités de première initiation, qu’au cours du XIe siècle on s’attacha à polir et à présenter sous une forme plus convenable. On pourra constater aussi, que ces premiers emprunts se sont effectués dans le domaine pratique, et concernaient notamment l’usage de l’astrolabe, du quadrant, de la sphère armillaire, des chiffres arabes, des recettes de médecine, des formules astrologiques, et moins vraisemblablement de l’abaque et, à cette époque, du calcul. La vitalité du Haut Moyen-Age était encore trop faible pour pouvoir s’assimiler les grands traités scientifiques des Arabes ou leurs systèmes philosophiques.” An important indication of the science-historical significance of this incompetent and dishonest manner in which the Arab–Islamic sciences were appropriated in the mediaeval Christian West, and the resulting interest in the knowledge to be borrowed from Arab Spain, can be seen in the fact that bishop Fulbert of Chartres (ca. 975–1029) compiled a glossary of 28 Arabic terms from available texts on the astrolabe.

The impact of the first wave of translations and imitations of Arabic works issuing from the re-conquered parts of Spain seems to have been limited at first to the immediately neighbouring region. The big translation-vogue only began at the turn of the 12th century. In the 11th century, after the work of Hermannus Contractus (d. 1054), we only encounter Walcher of Malvern towards the end of the century. He hailed from the Lorraine region to which Arabic astronomy and mathematics had found their way as early as in the 11th century; he was perhaps the first

European to have attempted successfully to determine the time-line of a lunar eclipse [138], which he accomplished in 1092 by observation with an astrolabe.\(^{306}\)

The grand scale introduction of Arabic medicine by Constantinus Africanus in the second half of the 11th century shall be left aside here in this treatment of the west European part in the process of reception; it was mentioned already (supra p. 91 ff.) and shall once more be considered below in the context of the second route of reception and assimilation of Arab–Islamic sciences in the West.

After a possible first encounter in the early 9th century with sciences cultivated in the Islamic world, and their reception from the second half of the 10th century, the further development of which in the 11th century we can as yet not trace in detail, the first half of the 12th century brought about a great tide of translations from the Arabic into Latin and Hebrew. One of the leading pioneers of this movement was Adelard of Bath (active 1116–1142, supra p. 98). He, Robert Grosseteste (d. 1253) and Roger Bacon (d. 1292) may be regarded as the three foremost English scholars of the period of reception and assimilation. After long sojourns in Laon, Tours, Salerno and perhaps Syracuse as well as Tarsus and Antioch, he returned to England in 1120. With numerous translations and his own works he introduced, above all, a new astronomy and mathematics into Europe. With the translation of the \(\text{Zi}\)\(\ddot{g}\)\(^{307}\) of the above mentioned Mu\(\ddot{h}\)ammad b. Mü\(\ddot{a}\) al-\(\ddot{H}\)wärizmi in the revision by Abu l-Qāsim Maslama b. Ahmad al-Ma\(\ddot{g}\)śli (d. 398/1007), he acquainted his contemporaries with a handbook of Arabic astronomy which had already developed distinctive traits both in theoretical and in applied branches, on the basis of assimilated Indian and Greek works on the subject. The trigonometry and the trigonometric tables transmitted by the book, prepared the grounds for a future expansion of mathematical, astronomical and geodetic knowledge in Europe. Raymond Mercier\(^{308}\) may be right in his comment that the Latin world was still not at all ready for such a work, resulting in the very slow pace of the process of assimilation, yet we should consider how long it would have taken the Europeans to create the knowledge of mathematics and astronomy, which they had acquired through translations from the Arabic, on their own.

Two further contributions of pivotal importance for mathematics and astronomy made by Adelard of Bath are the translations of the same al-\(\ddot{H}\)wärizmi’s Arithmetic and of Euclid’s \textit{Elements} from the Arabic.

The big stream of translations which the history of science knows from the 12th century was fed predominantly from Toledo. This city, conquered in 92/711 by the Arabs, had developed in the course of time into a scientific centre of high order and, with its scholarly tradition of collaboration between Muslims, Christians and Jews and with its great libraries, [139] came under Castilian rule in 478/1085. The scientific activities that developed after the fall of the city were described by Valentin Rose\(^{309}\) in 1874 as “nursery (Pflanzstätte) of the ‘doctrina Arabum’” for all Europe.

As early as in the first half of the 12th century, the first and decisive phase of the reception activities in Toledo, amazingly extensive


\(^{307}\) v. F. Sezgin, op. cit. vol. 6, p. 142.

\(^{308}\) \textit{Astronomical tables in the twelfth century}, op. cit. p. 87.

translations were accomplished which would have been inconceivable without a preceding tradition—dating back to the Islamic rule—of cooperation between individuals of all three creeds. In this connection we may recall that in the 12th century, several generations after the reconquest of Toledo, the language there was still predominantly Arabic, albeit a vernacular, not literary Arabic (infra p. 143 under Gerard of Cremona).  

The Mozarabs in turn “had maintained their churches, their Romanic dialect, their Visigothic traditions under their Muslim conquerors until the middle of the 12th century and, above all, also for a long time, their civic and legal rights… Thus they remained a people of their own, although in some respects they knew how to assimilate, in particular also in terms of language.”

The list of works translated by Johannes Hispalensis can give us an idea of the extent of the achievements of those times. This Jewish apostate, who converted to Christianity, translated about twenty works from the fields of arithmetic, astronomy, astrology, medicine and philosophy from Arabic into Latin, including the Handbook of Astronomy by al-Farānī (1st half 3rd/9th c.). Thus, after al-Øw®rizm¬’s book, there was a second astronomical work available which—thanks to repeated translations—was to stay very popular with Western astronomers until well into the 17th century. Johannes Hispalensis was also the first to make at least seven Arabic works of philosophy available in Latin translation, including writings by al-Kindi, al-Fārābī and al-Øazzālī.

Robert of Chester (Robertus Castrensis, Retinensis etc.), an Englishman who had lived in Spain from around 1141 to 1147, in collaboration with his compatriot Hermannus Dalmata, made the first Latin translation of the Koran. His great achievements also include the translation of the algebra book of the repeatedly mentioned Muhammad b. Mūsā al-Øw®rizm¬ from the early 3rd/9th century, through which he became the first to introduce the term algebra and the mathematical processes connected with it into the Christian West.

The use of the word *sinus* (“bosom”) being a literal translation of the misread Arabic term *gāib* (instead of *gib* [140] for Sanskrit *jiva*) goes back to him as well. Robert of Chester was also the first to translate works on alchemy from the Arabic into English.

One of the most important works rendered into Latin in Christian Spain at this time is the Hand- book of Astronomy by Muhammad b. Ġābir b. Sinān al-Battānī (d. 317/929). Through this work, which was translated by Plato of Tivoli (who lived in Barcelona from 1134–1145) and again by Robert of Chester, whose version is not extant, in addition to the already mentioned works by al-Øw®rizm¬ and al-Farānī, the Latin world encountered a number of processes and concepts from the field of astronomy which had meanwhile been developed in the Islamic world.

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317 ibid, p. 176.

After this short survey of works translated from the Arabic into Latin in the first half of the 12th century, we shall also mention several scholars of the time who contributed to the assimilation of Arab science not only with translations but by then also with their own compilations. An interesting exponent of this group was Hermannus Dalmata or Hermann of Carinthia who, with Robert of Chester, translated the Koran. He lived from 1138 to 1142 in Spain and 1143 in Toulouse. Besides the translations of astrological books and of the notes on Ptolemy’s Planisphaerium by the above-mentioned Abu l-Qāsim Maslama b. ʿAlī (d. 398/1007), we know several books that are ascribed to him and one work of his own with the title *De essentiis*, which he dedicated to Robert of Chester. This philosophical work, written in 1143, is a conglomerate of text passages from Arabic and Latin sources.

As a compiler along a similar line we encounter Raymond of Marseilles in his *Liber cursuum planetarum* composed from 1139 to 1140. With this book on astronomy and the geographical table contained therein—which stem from Arabic sources—he intended to render a service to his compatriots. Besides al-Battāni, he relied on the Toledan Tables and the Canon (al-Qānin) of az-Zarqālī, whom he wanted to emulate. His geographical table contains the coordinates of 60 cities. Thus he was one of the first, if not indeed the first, Latin writer to make an Arabic coordinate table widely known in Europe. His book was still to be found amongst the sources of Roger Bacon and was probably also used by Albertus Magnus (supra p. 103).

The Jewish scholar Abraham bar Ḥiyya alias Savasorda (from Arabic ṣāḥib as-ṣurra, “prefect of the watch”), who lived in the first half of the 12th century in Barcelona, should be mentioned here. His influence was not directly exerted through Latin translations, but his Hebrew writings in which he transmitted the contents of a large number of Arabic sources in his own words. According to George Sarton, he was one of the initiators of the movement in which Jews from the Provence, Spain, and Italy became mediators of Islamic science in the Christian West. A complaint of his, namely that Arabic sciences were little known in the Provence, is known. In his book *Hibbur ha-mešiḥa ve-hatiḥoret* he presents the basic elements of Arab algebra, geometry and trigonometry at a high level. Through the Latin translation of this book by Plato of Tivoli (1145), entitled *Liber embado-rum*, he exerted a not insignificant influence on the development of mathematical knowledge in Europe, even if the aspects of Arab mathematics he covered had reached the West through different channels before him. He probably also played some role in the transmission of Arab music theory into the West.

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Amongst the subsequent translators whose activities lay mostly between 1150 and 1200, we may consider Dominicus Gundissalinus as the first exponent of assimilation. He stands out not as much as a translator but with books he compiled from his translations. In the case of the treatise *De celo et mundo* which he, in collaboration with Johannes Hispalensis, brought into circulation as a work by Ibn Sinā and that was accepted as such for centuries, it was proven by Manuel Alonso\(^{328}\) that the true author was Hunain b. Ishāq\(^{329}\) (d. 260/873). Gundissalinus’ best known and most important book *De divisione philosophiae* is also, in large parts, copied from *Iḥṣā‘ al-‘ulūm* by Abū Naṣr al-Fārābī\(^{330}\) (d. 339/950). He seems to have used Latin models (e.g. Boëthius) and works by Ibn Sinā and al-Gazzālī as well, but he does not mention them as sources. In a commendable study Ludwig Baur\(^{331}\) investigated the sources of Gundissalinus’ *De divisione philosophiae*. He discovered that it was suspected to be a work by al-Fārābī quite early on. “Considering the generous use of Al-Farabi’s work (de scientiis) by Gundissalinus it is hardly a surprise that this suspicion could arise.”\(^{332}\) Baur called the book a “free compilation.”\(^{333}\) “Gundissalin’s compilatory method of working, as alien and inappropriate it may seem to us, must not surprise us: it was standard throughout later Antiquity and the Middle Ages… This kind of literary activity should, I believe, be seen in closest connection with the whole philosophical conception of knowledge and the pedagogic vocation, which separates Antiquity and the Middle Ages from modern times.” About the mind set of the Middle Ages he says: “There we have a philosophy which believes in the possibility of definite, \(^{[142]}\) objective, and permanent cognition of truth. All scientific interest was concentrated on truth as such, aiming for the discovery of truths to be firmly established once and forever. Those truths were public domain, and it was quite irrelevant who found them.”\(^{334}\) This explanation may be generally correct for the Latin authors and to some extent also for the ancient Greeks, the Arab–Islamic world, however, must be excluded from it. Unfortunately, too little attention has as yet been paid in the historiography of sciences to the fact that references to the sources was one of the characteristic traits of Arab–Islamic literature, which of course does not mean to say that there was no plagiarism or that all authors observed this general rule.

The manner in which Gundissalinus treated his sources and in particular the works of his Arab predecessors which he used in translations and perhaps also in the original, is characteristic of all works that bear his name.\(^{335}\) Baur\(^{336}\) also discovered that besides Gundissalinus’ *De divisione philosophiae*—which is “based upon a number of Arabic authors”—there was “a second [book] which was probably written in the beginning of the XIIIth century and which


\(^{329}\) F. Sezgin, op. cit. vol. 3, pp. 247–256.

\(^{330}\) ibid, vol. 3, pp. 298–300.

\(^{331}\) Dominicus Gundissalinus, *De divisione philosophiae*, Münster 1903 (Beiträge zur Geschichte der Philosophie des Mittelalters, vol. 4, part 2–3).

\(^{332}\) ibid, p. 160.

\(^{333}\) ibid, p. 161.


likewise must have been completely Arabic in character: The *Divisio philosophiae* by Michael Scotus.” Surviving fragments of this book show that it was a compilation using the work of Gundissalinus and Arabic sources. This way of dealing with Arabic sources and their contents is a science-historic phenomenon which we encounter not only with Gundissalinus in the history of the reception and assimilation of the Arab–Islamic sciences in the West. We of present times must understand this as a typical practice of that civilisation at the time and we must take it into account accordingly. Hence historiography is called on to revise—assisted by Arabist research—the prevailing notions about the history of European science, particularly regarding the period between the 11th and the 13th century, in the light of the actual facts.

In the 12th century the process of translating Arabic and adapted Greek works from Arabic into Latin and Hebrew (which had already begun in the 10th century) reached its apogee, at a time when the sciences in the Arab–Islamic world were progressing creatively in almost all areas. The important development connected with the name of Gerard of Cremona is a phenomenon in the history of science that will perhaps remain for a long time without a well-founded explanation. Born around 1114 in Cremona, Italy, he moved to Toledo where he was active until his death in 1187. We know almost nothing about the life of this undoubtedley greatest translator of Arab–Islamic writings into Latin. Probably he was a cleric, like most translators of those days. A list of his translations compiled soon after his death contains seventy-one [143] titles arranged by subjects:

- twenty of them deal with *dialetica* (logic and geometry),
- twelve with *astrologia* (mainly astronomy),
- eleven with *philosophia* and twenty-eight with *fisica* (medicine and others).

To what extent this anonymous list—which is appended to some manuscripts of the Latin translation of the commentary by ‘Ali b. Ridwan (d. 453/1061) on Galen’s *τέχνη ιατρική*—conforms with reality is of course uncertain. Moreover, as G. Sarton already pointed out, further translations kept being ascribed to Gerard of Cremona later on, either erroneously or because of his fame. Sarton also drew attention to the fact that many of the first printed editions of translations attributed to Gerard of Cremona do not bear his name. Hence the ascriptions should not be taken too literally. For an Italian who went to Toledo as an adult and only there learned Arabic, the task of translating scientific works on all kinds of subjects from Arabic to Latin was certainly not easy. One should also bear in mind that Muslim scholars had left Toledo after the reconquest in 1085 and the only people left who spoke Arabic were the Christian Arabs (Mozarabs). Whether they could have been of much help with philological and terminological difficulties is however rather doubtful. In an article on Gerard of Cremona’s translations, Paul Kunitzsch gives an apt description of the linguistic situation in the reconquered Toledo: “What was the standard of knowledge of the Arabic language on the side of the translators? Regarding Gerard specifically, we know that he came to Spain from Italy, that means that he could not have had any knowledge of Arabic in advance. He will have learnt the language in Toledo. But what sort of Arabic is it that he could have learnt there? The

areas dominated by the Arabic language are known for their ‘diglossia’, that is that there existed—and still exists today—two languages side by side: the spoken colloquial Arabic generally used in oral speech, and the language of writing which is strictly dominated by the rules of the fushā, the classical literary Arabic.”

In connection with the question of people from Toledo helping out with language skills, Daniel of Morley (last third of the 12th century), who spent some time in Toledo, is often quoted. In his *Philosophia*, he writes that Gerardus Toletanus was assisted in the translation of the *Almagest* by a Mozarab named Galippus (*Γάληβ*).

The difficult task of establishing, by a stylistic and terminological analysis, the true relationship of the seventy-one titles (mentioned on the list) to Gerard of Cremona has yet to be fulfilled. Leaving aside the fact that the list was compiled after his death, the manuscripts of the translations attributed to him as a rule do not include a colophon by him and, with a few exceptions, do not name him as the translator. At any rate, it is very unlikely that all the translations on the list are actually his. The number of works enumerated appears too large for a single translator and the vast range of subjects covered makes it difficult to believe that a man who had moved (from Cremona) to Toledo in his thirties, albeit a scholar of exceptional ability, should have been able to translate so many works into Latin. It is conspicuous that the list contains the names of some important works which had already been translated by others, such as the Arabic version of the *Elements* by Euclid, the *Algebra* by Muḥammad b. Mūsā al-Ḥwarizmi, or the handbook of astronomy by al-Fargāni. Nevertheless, we may assume that some of the works on the list are really original translations by Gerard of Cremona. Some extensive and extremely important works like Ptolemy’s *Almagest*, *al-Qānūn fī t-ṭibb* by Ibn Sinā and the section on surgery of *at-Taṣrif li-man ‘aḡiza ‘an at-taṣrif* by az-Zahrāwī are amongst them, besides books by Hippocrates and Galen. The *Almagest* was, incidentally, rendered directly from Greek into Latin by an anonymous translator in Sicily around 1150, roughly 25 years before the Arabic translation by Gerard of Cremona was completed. According to one scholar the translator may have been Hermann of Carinthia (Hermannus Dalmata). But whoever it was, the translation from the Greek did not gain any prominence in Europe. P. Kunitzsch came to the general conclusion that works of Arabic origin enjoyed greater authority than others in the European Middle Ages prior to the rise of anti-Arabism.

Leaving aside the question of the real translators, the fact still remains that this list of translations attributed to Gerard of Cremona contains no less than seventy-one works that were supposedly translated from Arabic in Toledo. Further works rendered by other translators into Latin must be added. All these works together provide us with a glimpse of the process of reception of Arab–Islamic sciences in the 12th century. Its importance for the upsurge of sciences in Europe has not yet found a truthful expression in the general history of thought.

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343 *Gerard’s translations of astronomical texts*, op. cit. p. 73.
2. The Route of Reception via Sicily and South Italy

When we follow Heinrich Schipperges’ delineation of the development in the field of medicine—according to which the reception started “in the cultural centres in southern Italy” and “after an extraordinary journey through Spain, France and England,” returned “again to its original civilisation” where the first wave of reception had emerged from “the school of Salerno” in which Constantinus Africanus (ca. 1015–1087) had played the leading role—the question still remains open as to whether the medical practice and literature, which had been intensively cultivated in northern Africa from the 9th century onwards, could not perhaps have already spread to Sicily under Islamic rule, and from there to the Italian mainland. After all, this large, central island in the Mediterranean reached a high cultural and social standard under the Arabs from the 9th century to 1086 CE.

The fall of Arab rule over Sicily did not immediately cause the new spirit and the new culture of the preceding two and a half centuries to wane. Under the third of the Norman kings, Roger II (r. 1130–1154), the Arabs still constituted a large part of the population. “Roger employed many Arab civil servants and thus enabled the re-organisation of Arab institutions. The land registers, the defetari [daftar = booklet, register], which had been taken over from the Muslim administration continued to be kept in Arabic.”

“Like the organisation of the financial administration, the royal silk workshops too revived an Arab institution called tirāz. The mantle of Roger II, which served the German kings as a coronation robe, was made in the Norma palace workshop.”

“The palaces and parks Roger owned in and around Palermo were influenced by Arab taste and were built partly on the remains of Arab buildings and gardens. They were Sung by Sicilian-Arab poets whose verses combine the praise of Roger with that of his parks and palaces.”

The technology of the Islamic world and the sciences cultivated there were a major inspiration for Roger II, even if we hear little about it today and know not enough. As an example we may mention the clepsydra that was constructed for him in Palermo in 1142. A white slab of marble 87 cm long and 49 cm wide still remains of it today. It is no longer in its original place but built into the wall at the entrance to the Cappella Palatina in Palermo. An inscription in Arabic, Greek and Latin provides testimony to Roger’s work. Following E. Wiedemann’s rendition, the Arabic text runs in English: “The Royal Majesty, revered and exalted, Roger, whose days God may prolong and whose colours He may support, had this instrument (âla) constructed in order to observe the hours in the capital of Sicily guarded [by God] in the year 536 [AH].”

As a clue to the question of what this clepsydra built for Roger may have been like, Michele Amari, the eminent expert on Arab Sicily, pointed to a report in a contemporary Arabic source, to the effect that an (Arab) engineer had built a water driven clock for the ruler of Malta with the figu-

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344 Die Assimilation der arabischen Medizin, op. cit. p. 185.


346 D. Schack, op. cit. p. 195.

347 ibid, p. 195.

348 ibid, p. 195.

349 ibid, p. 196.

350 Published repeatedly; on the Arabic text, see M. Amari, Le epigrafi arabe di Sicilia, part 1, Palermo 1875, p. 39.

The oldest Latin translation of an Arabic book known to have originated in Sicily was probably made upon the commission of Roger II. It was Ptolemy’s *Optics* translated by an admiral (or amir, amiratus regis Siciliæ) by the name Eugenios. The reason why no earlier translations from Sicily are known is certainly that prior to its re-conquest, the majority of the population of the island knew Arabic.

With regard to the reception and also the promotion of Arabic science, Roger deserves much credit since, thanks to his commission, with his support and to a certain extent even his personal participation, a geographical work and a world map were produced. It is the geography by as-Ṣarif al-Idrisi entitled *Nuzhat al-muštaq fi ḥtirāq al-ajāq* and his world map which was engraved on a large silver plate (supra p. 37 ff). It is one of the oddities of the history of science that the book as such did not stir any noteworthy interest in Europe up to the 17th century. The world map, however, already seems to have exerted a profound influence on European cartography soon after it was made and continuing until the 18th century.

These first sporadic impulses emerging in Sicily from Arabic works in the original or in Latin translation can be regarded as signs of a period of incubation in the reception and assimilation of the culture and the knowledge of the neighbouring civilisation. The latter had been known for a long time, but from the end of the 11th century a completely new relationship was established. As far as we can judge from today, it is one of the most significant coincidences in the history of science that three important centres of science and culture in the Arab–Islamic world, with all their cultural assets and technical as well as scientific achievements, almost simultaneously fell into the possession of the Christian–Latin civilisation towards the end of the 11th century. In 1085 Alfons VI of Castilia conquered Toledo, in 1091 Roger I seized Sicily from the Arabs; while on the other hand a considerable part of greater Syria including the cultural centres between Antioch and Jerusalem, came under the rule of the Latin crusaders—who referred to as “Orient-Latins” in the literature—for approximately 200 years with interruptions, between 1099 and 1291. In the process of reception and assimilation of the sciences cultivated in the conquered and reconquered areas, the exponents of the cultural centres in the south of Italy and in Syria had a certain advantage over the western European centres. In Spain the translation activities had begun as early as in the 10th century and kept growing continuously, while the assimilation of newly acquired knowledge had already made considerable progress. The ‘Orient-Latins’ on their part had the opportunity to benefit from both the progress made in the European centres and, during their two hundred years of contacts with the centres of Arab–Islamic culture, from local sources and achievements which had not found their way to Europe via Spain for various reasons, including that they were too recent.

The process of translating available, mostly classical works which was cultivated in the centres of western and north-western Europe from the 10th century, having expanded considerably in the course of 150 to 200 years, eventually also reached Italy. The translations made in the southern Italian area are known thanks to the work of

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With the new channel opened by the ‘Orient-Latins’—which was more of an immediate connection than a route—the process of reception assumed an entirely new character. In the 12th and 13th centuries, when Arab–Islamic sciences had reached their zenith both in theory and practice, the ‘Orient-Latins’ bridged the distance between southern Italy and the centres of the Islamic world across the Mediterranean. The reception was no longer restricted to the translation of books, more often than not dictated by chance than by design. Under the new circumstances, even if they were often disturbed by bellicose relations, one had the opportunity to learn directly about new and old, yet unknown achievements such as scientific and technical instruments and devices, weapons or also certain institutions, and to get to know the contents of books from Arabic-speaking Christian teachers without bona fide translations. Cultural centres like Antioch, Edessa, Laodicea (Latakia, Arabic: al-Lāmīqiyā) and Jerusalem thereby gained a leading role under the ‘Orient-Latins’.

This straight-forward presentation of the phenomenon should however not create the impression that I would not be aware of the ‘catastrophy-theory’ quite common in the 18th and the 19th centuries, according to which the reception of Arabic sciences was predominantly a consequence of contacts resulting from the crusades. Yet my opinion is comparably more nuanced, with emphasis on the fact that the crusaders, who had experienced the superiority of Arab–Islamic sciences had the opportunity to encounter the latest achievements and knowledge in the centres of the Islamic world and to transmit these to Europe, in a fairly advanced phase of the reception and over a period of 200 years. This process may be illustrated by a few examples.

The cosmographer Zakariyā’ b. Muhammad al-Qazwīnī (b. ca. 600/1203, d. 682/1283) reports “that at the time of al-Malik al-Kāmil the Franks sent problems to Syria for the solution of these. Amongst them were medical, philosophical and mathematical questions. The scholars of Syria solved the medical and philosophical problems themselves, while they could not cope with the mathematical ones. But al-Malik al-Kāmil desired that all problems be solved and therefore sent them to Mosul [al-Maušīl] to al-Mufaḍḍal b. ‘Umar al-Abhari, our teacher who was unequalled in the science of geometry, but all the same the solution was too difficult for him. He showed the problem to master Ibn Yūnis [Kamāladdīn, d. 639/1242], who thought about it and solved it. The task is this: Take an arc, draw its chord and extend it beyond the arc; on the extended chord draw a square the area of which shall be equal to that of the segment. This is the figure:

Al-Mufaḍḍal [al-Abhari] added a proof to the solution, wrote a treatise on it and sent it to al-Malik al-Kāmil in Syria.”

354 Die europäischen Übersetzungen aus dem Arabischen, op. cit.
The spokesman of “the Franks” was Emperor Frederick II of Hohenstaufen (r. 1212–1250), the addressee the Ayyubid Sultan Nasiraddin Muhammad al-Malik al-Kamil (r. 615/1218–635/1238), who had ceded Jerusalem to Frederick by an agreement in the year 626/1292. Putting aside the question of how Frederick came to or from where he got such a difficult mathematical problem, let me first give another example:

Frederick II put seven questions from the field of natural sciences to al-Malik al-Kamil with the request to have them answered by his scholars. The Cairene juristprudent Shihabaddin Ahmad b. Idris al-Qaraf (d. 684/1285) preserved some of the questions together with other questions on natural sciences in a special treatise called Kitab al-Istibbar fimu tudrikuhu l-absar. Amongst the questions posed by Frederick II were, inter alia, the following:

1. Why does one see oars, lances and all straight bodies of which a part is submerged in clear water, as bent towards the surface of the water?

2. Why does one see Suhail (Canopus) larger at its rising than at its highest position, although in the south there is no moisture—which, in the case of the Sun (viz. at the corresponding altitudes) is used as an explanation (of this phenomenon)—because the southern areas are dry deserts?

As a third example from the “Sicilian questions” of Frederick II we may cite some that are of a philosophical nature. He addressed them to the Almohad sovereign ‘Abdalwahid ar-Raсид (r. 630/1232 to 640/1242). The philosopher and mystic ‘Abdallhaq b. Ibrahim Ibn Sab’in (b. 613/1216 or 614, d. 668/1270 or 669), at that time staying in Ceuta, was charged with the task of answering them. The first question put by the emperor runs thus: “Aristotle the sage teaches in all his writings the eternal existence of the world. Nobody doubts that this was his opinion. If Aristotle has proven that, what are the arguments that he used?”

The second question: “What is the purpose of metaphysics? What are the required propaedeutics if any?”

The third question: “What are categories? In which way do they serve as keys to the diverse areas of knowledge? What is their true number? Can they be increased or reduced? Which approaches to reasoning and proof should be considered in this regard?”

The fourth question: “What is the proof for the immortality of the soul if it is indeed immortal? What is the position of the sage Aristotle on this question as opposed to Alexander of Aphrodisias?”

The fifth question refers to a quote from the Prophet Muhammad.


361 C. Brockelmann, op. cit. vol. 1, p. 465, suppl. vol. 1, p. 844.

The questions on natural sciences, philosophy and even theology put to the Arab princes are not the only indication that the presence of the crusaders in an important part of the Islamic world had opened up an entirely new scenario for the process of becoming acquainted with local cultural assets and for their assimilation. This intellectually open atmosphere assumed a special quality with Emperor Frederick II and his personal inclinations and private encounters with sovereigns and scholars.

It is highly gratifying that in the past decade several commendable attempts have been made to investigate, in special events, the presence of the crusaders in Palestine from the viewpoint of history of science. Considerable progress was made away from the previously favoured view that the crusaders were not to be taken into consideration for the process of the reception of science and technology of the Arab–Islamic world; the contributions give rise to hopes that an appropriate correction in the historiography of sciences may be achieved in the near future. When Raymond Mercier in his substantial contribution comes to the conclusion that from his point of view the crusaders have to be ruled out as mediators of knowledge in “mathematical astronomy”, then this is to be understood in the sense of translations of astronomical books. Yet undoubtedly many a crusader did come across one or the other of the astronomical instruments in widespread use during his stay in the Islamic world and brought such a device back to Europe on his return. Thus the “Orient-Latins” will frequently have become middlemen for processes regarding making and using of instruments, tools, weapons or drugs which they got to know, not by reading books but through personal contacts during their stay in Syria. The positive side-effects of the crusades in the field of astronomy include, for instance, the golden planetarium that Emperor Frederick II received in the year 629/1232 as a gift from al-Malik al-Kāmil (or from Mūsā b. Muhammad al-Malik al-Āṣraf, r. 626/1228–635/1237 in Damascus). “When Frederick showed his precious planetarium in which Sun, Moon and stars moved in curious harmony, in later days to particularly distinguished visitors, he loved to say that this gift from his Arab friend, the Sultan, was so dear to him, it came second in his love only to King Konrad, his son and heir.”

Frederick kept the planetarium in Venosa. The supposedly French type of astrolabe with the lower equatorial bar (infra II, 101) and the mechanical Franco-Gothic lunar calendar (infra II, 170) are in my assessment also likely to
have come to western Europe through channels opened up by the ‘Orient-Latins’.

The investigation into instruments and techniques that have reached Europe from the Arabic area via the transmission lines of this category, must, in my view, be assigned the highest priority in the future historiography of sciences. In my view gained through intensive occupation with the subject weapons in particular, improved or invented in the Arab—Islamic area, were adopted and used as quickly as possible by the crusaders and brought to Europe with minimal delay on the transmission routes in question. This includes the winch crossbow, an improved variety of a weapon known already to the Greeks and the Romans. The decisive new element of this variant consisted in a winch which substantially facilitated the drawing of the large bow. There is historic evidence that such a crossbow was used against the crusaders in the year 647/1249 near al-Manṣūra in Egypt (infra V, 94). When in the year 636/1239 Emperor Frederick II ordered a captain sailing to Acco (‘Akkā) to purchase *tres bonas balistas de torno et de duobus pedibus*, in all likelihood this also referred to the same type of crossbow (infra V, 94).

We should also mention the counter-balance trebuchet which appeared in the Arab—Islamic area in the early 13th century and soon afterwards was also used by the Europeans. It was a considerably more advanced type of catapult known already to the Greeks and the Sasanid Persians (infra V, 96).

It is highly probable that the knowledge of firearms which reached Europe towards the end of the 13th or at the beginning of the 14th century came from the Arab—Islamic area as well. If it was not transmitted directly by the crusaders, then it came to Europe on a route via southern Italy (infra V, 101).

A certain type of mariners’ compass (infra III, 60) appears to have reached Europe on this route as well. It is described in an epistle, written in around 1270 by the French scholar Petrus Peregrinus, who got his sobriquet as a partici-


368 v. F. Sezgin, op. cit. vol. 11, pp. 252, 325.

Islamic sciences in the Christian-European culture, a comparison of surviving works from both cultural areas under this aspect would appear promising to me. While occasionally consulting Latin and Italian illustrated works such as those by Conrad Kyeser (1405), Mariano Taccola (1433), Leonardo da Vinci (1519), Georgius Agricola (1556), Agostino Ramelli (1588) or Fausto Veranzio (1615), it occurred to me that they must have been strongly influenced by Arabic sources.

The examples meant to give a certain idea of the second route of reception and assimilation of Arab–Islamic sciences via southern Italy shall conclude with the mention of three scholars whose works were the subject of recent research. They are Stephanus of Antioch (first half of the 12th c.), Leonardo of Pisa, known as Fibonacci (ca. 1170 – ca. 1240), and Theodorus of Antioch (d. 1250).

Stephanus of Antioch hailed from Pisa and went, possibly as a crusader, to Antioch where his uncle held the office of patriarch. He learned Arabic and took up the task of making a new translation of the handbook of medicine by ‘Alb. al-‘Abbâs al-Ma‘âsû (4th/10th c.), which had been rendered incompletely by Constantinus Africanus and, what is more, circulated as the latter’s own work. It appears that Stephanus realised that the Liber pantegni was not by Constantinus Africanus only when he saw the Arabic original in Antioch (supra p. 91). In another book, called Liber Mamonis, Stephanus appears as an assimilator of Arabic sciences. In this astronomical work he does not conceal the fact that he follows an Arabic precursor, although he does not give his name. It is remarkable that numbers are expressed in Arabic numerals.

[152] While in Christian scholarly circles of the 12th century rather the study of Greek and Hebrew—for the sake of biblical studies—was encouraged, Stephanus speaks of arabica veritas in which one finds nourishment for the body as well as for the soul.

Leonardo of Pisa (Fibonacci), together with Theodorus of Antioch, belonged to the circle of scholars around Emperor Frederick II and is considered to be “the first great mathematician of the Christian West”. His father being the head of the merchant colony of Pisa in Bugia (Bigâya in today’s Algeria) from 1192, he had the opportunity to come into contact with Arab scholars and to travel, in the company of his father and also on his own, to Egypt, Syria, Greece, Sicily and southern France. After his return to Pisa, he composed five works on arithmetic, algebra and geometry. Although his books are not the first ones written on these subjects in the Latin language, yet they stand out with clarity and versatility, and their special importance lies in their author’s treatment of linear and quadratic equations with a comprehension and lucidity unknown in Europe up to his times. There is no doubt that his sources were translations of Arabic works, and it is also not ruled out that Leonardo, during his stay in Algeria and his visit to other Arabic countries, also came across mathematical works in the Arabic original and later took them to Pisa. His position in the history of the reception and assimilation of Arabic mathematics should be seen in the fact that he acquaint-
ed the Latin reader with the topics and contents of his Arabic sources in surprisingly successful compositions, not without adding some lessons of his own. In doing so he certainly did not cover all the important problems and results of Arab–Islamic mathematics that were available to him. The particular merit of his presentation lies in the treatment of arithmetic and algebra on the basis of the decimal place value system.

Fibonacci was apparently the first mathematician in the West to express the concept of zero with the term *cephirum*, borrowed from Arabic *ṣifr* (which eventually became *zero* in Italian).\(^{375}\) In 1202 the fraction stroke to separate the numerator from the denominator appears in his writings, from which we can assume that he was familiar with the use of this notation amongst west-Arabic mathematicians, as for instance in Abū Zakariyyāʾ Muhammad b. ‘Abdallāh b. ‘Ayyāš al-Ḥašṣār\(^{376}\) (6th/12th c.).\(^{377}\)

Leonardo’s much higher mathematical standard compared with his European contemporaries can probably be explained with the fact that, on the one hand, during his relatively long stay in Arab countries he was in the position to acquaint himself with Arabic sources that had not yet reached Europe and that, on the other hand, he had the opportunity to sharpen his insight in the matter in lectures and discussions during his contacts with Arab–Islamic mathematicians. Raymond Mercier\(^{378}\) described Leonardo’s exceptional situation from his point of view \([153]\) in the following words: “The Latin world of the 12th century was not so privileged. Here the transmission was almost entirely through books, even when the Latin translations were made in Toledo, or elsewhere in Andalus. There must have been very little contact with the living mathematical practitioners in the Arabic or Hebrew speaking world. An exception appears to be provided by the 13th century mathematician Leonardo of Pisa (Fibonacci), who as we understand, had direct access to the mathematical community in Islamic North Africa, at Bijāya (modern Algeria). The brilliant creative work which he produced shows well what could be achieved in the Latin world when living teachers were involved. The history of Latin science from the 12th to the early 16th centuries is largely one of a struggle to transcend book learning. Only at the end of that long period do we observe Europeans as true masters of scientific subjects.”

As the third of the scholars contributing to the reception of Arab–Islamic sciences on the route via Sicily and Italy, we shall mention Theodorus of Antioch. Unlike the two aforesaid scholars he was not from Pisa, but was a Christian Arab who had been in the service of Frederick II in Sicily as a scholar and advisor for some time. The Syrian-Christian scholar Abu l-Faraj Ibn al-‘Ibri (Bar Hebræus, d. 1286 ce) gives an interesting biographical account which draws a vivid picture of the life and work in a community of scholars of different creeds and shows that this essential characteristic of intellectual culture in the Islamic world continued to exist even under the rule of the crusaders. Bar Hebræus’ narrative\(^{379}\) reads in translation:\(^{380}\) “Tādir of Antioch


\(^{378}\) East and West contrasted in scientific astronomy, op. cit. p. 236.

\(^{379}\) Taʾrīḥ muḥtaṣar ad-dawal, ed. Šāhāni, Beirut 1890, pp. 477–478.

[al-Anṭāki], a Jacobian Christian accomplished himself in the Syrian and Latin language and in the sciences of Antiquity while in Antioch, then he travelled to Mosul [al-Mausil] and studied under Kamāladdin b. Yūnis the works of al-Fārābī, Ibn Sīnā, Euclid and the Almagest. Then he returned to Antioch, but did not stay there long because it had become clear to him that here he could not further advance his knowledge and so went to Kamāladdin b. Yūnis at Mosul for a second time and deepened his knowledge. Then he went to Baghdad, perfected himself in the science of medicine, studied its achievements and mastered its special applications. He wanted to enter the services of Sultan ʿAlīaddin (Kayqubād, r. 618/1220–634/1237), but the Sultan did not show any inclination. Then he went to Armenia and entered the services of Constantine, the son of King Ḥātim (Heṯum I), but he found their society (their attitudes) not agreeable and therefore he travelled with an emissary of the Imbār (Emperor), the king of the Franks to the same, from whom he received kindnesses and in whose favours he was. He even invested him with a complete city and its surroundings…”

This versatile scholar with his well-founded knowledge of Arabic sciences seems to have assumed a prominent position in scientific life, shortly after his admission to the court of Frederick II. It seems justified to assume that he contributed substantially to the mathematical, scientific and philosophical queries sent by the Emperor to al-Malik al-Kāmil or Ibn Sabʿīn (supra p. 147 ff.). In this regard it is also remarkable that Leonardo of Pisa corresponded with Theodorus on mathematical matters. Leonardo wrote him a letter which contained problems leading to indeterminate equations of the first degree. “Theodorus, in turn, sent Leonardo a problem from indeterminate analysis of the second degree which Leonardus solved in his Liber quadratorum”. No doubt Theodorus had an important part in the introduction and dissemination of Arabic works in Sicily and southern Italy. We know that he translated for the Emperor a book on falconry into Latin which is extant under the title Moamin and largely has the character of a veterinary book. The Arabic original was probably related to the falconry book which was translated into Spanish on commission by Alfonso X about a quarter of a century later. It is not surprising that the Emperor himself composed his own elegant book on the basis of the former and other sources, his own experiences and in collaboration with Arabic falconers whom he had drawn to his court—to use his own words—“at great expenses”. It was entitled De arte venandi cum avibus (“On the Art of Hunting with Birds”).

3. THE ROUTE OF RECEPTION VIA BYZANTIUM

This route of reception of Arab–Islamic sciences led from the centre and the eastern parts of the Islamic world to Byzantium and from there to Europe. Hermann Usener already became aware of manuscripts containing
Byzantine translations of Arabic–Persian books in European libraries a hundred and thirty years ago. Subsequent research also occasionally drew attention to translations of Arabic books into Byzantine Greek as, for example, Symeon Seth’s translation of the collection of fables *Kalila wa-Dimna* (end of the 11th c. CE) from the Arabic version that ‘Abdallâh Ibn al-Muqaffa’ (d. 139/756) had compiled from the Middle Persian version, or the anonymous translation of the book on medicine, *Zâd al-musâfr* of Ahmad b. Ibrahim Ibn al-‘azzâr (d. 369/979), whose translator betrays the knowledge of further Arabic sources.

After a rather long interruption the question of the knowledge of Arab–Islamic sciences in Byzantium once again attracted the attention of historians of science, especially after Otto Neugebauer had discovered the drawing of a model of the Sun with a double epicycle in the Greek translation of an astronomical book in a Vatican manuscript. While it had been established for several years that Copernicus was influenced by Arab–Islamic astronomers in his attempt to restore the principle of the uniform motion of the planets violated by Ptolemy’s *Almagest*, this new find provided a lead in the issue of how that influence was transmitted. After the preliminary work by O. Neugebauer and E.S. Kennedy, subsequent scholars took the view that the relevant Arabic and in particular also Persian books on the latest planetary theories of Islamic astronomy found their way to Europe via Byzantine versions. Since then several studies and text editions by David Pingree (Brown University), Joseph Mogenet and his successor Anne Tihon (both Louvain) have considerably expanded our knowledge about the reception of Arabic astronomy and astrology amongst the Byzantines.

In an attempt to sum up the results achieved up to 1976, Mogenet asks himself regarding the attitude of the Byzantines towards Arab astronomy between the 9th and the 14th century, to what extent one might speak generally of acceptance or of resistance. With his colleagues from Louvain, he was inclined to see two distinct periods in the Byzantine attitude, the first lasting from the 9th to the 13th centuries and the second from the 13th to the 14th centuries. He argues that in the second phase a kind of renaissance in the field of science came about in which contact with Arab–Islamic sciences was decisive. Yet the influence of Islamic sciences was felt also in the first phase which Mogenet calls “traditionalist” and in which astronomy had enjoyed less prominence than astrology.

His successor, Anne Tihon, while characteris-
ing the astronomical–astrological pursuit in this first phase, comes to a somewhat more nuanced view by distinguishing two currents. The first of these currents was on a fairly elementary level. The second was characterised by the introduction of Islamic astronomical tables.

The earliest evidence that we know so far for an acquaintance of the Byzantines with Arab astronomy are comments on the *Almagest* dated 1032. Their anonymous author undertakes a critical comparison between Ptolemaic astronomy and that of the “moderns” (νεότεροι), meaning the Arab astronomers. [156] He uses the tables of one Ἀλλήμ who is today identified as Abu l-Qāsim ‘Alī b. al-A’lam al-Baghdādi (d.375/985). [402]

The second oldest testimony dates from around 1072. It is an anonymous Greek compilation from the *Zīg* by Ḥabaṣ al-Ḥāsib (d. end of 3rd/9th c.), the commentary by Ahmad b. al-Munānā (5th/11th c.) on the *Zīg* of Muhammad b. Musā al-Ḥwārizmi (1st quarter of the 3rd/9th c.) and from an Arabic astrological book. [406] The most significant feature of this manuscript seems to be that the sine and versed sine functions occur here for the first time in a Greek text (going back to the *Zīg* of Ḥabaṣ). [407]

A more recent compilation which is quite illuminating for our topic dates from the end of the 12th century and is found in the Codex Vat. gr. 1056. In this compilation of predominantly astrological content the names of roughly twenty Arab, Indian and pseudo-Indian authors are mentioned. [409] Explicitly cited are al-Ḥwārizmi, Ḥabaṣ al-Ḥāsib, Kūšyār b. Labbān and the ḥākimite* tables by ‘Alī b. ‘Abdarrāḥmān Ibn Yūnis. While studying the star tables in this compilation, Paul Kunitzsch [410] found “indisputable evidence of Arabic-Islamic origin”. With regard to the stellar nomenclature he noticed [411] that “although they were all designated with Greek expressions,” these were “frequently not the actual Greek, i.e. Ptolemaic names but literal translations of Arabic ones.”

The compilation also contains the translation of an Arabic treatise on the astrolabe in which several Arabic technical terms were left untranslated and rendered in Greek transliteration (as κότπ = qutb). [412]

In this connection we should also mention the only known “Byzantine” astrolabe. [413] According

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399 J. Mogenet, Une scolie inédite du Vat. gr. 1594 sur les rapports entre l’astronomie arabe et Byzance, in: Osiris (Brügge) 14/1962/198–221.
400 Anne Tihon, L’astronomie byzantine (du Ve au XVe siècle), in: Byzantion (Brussels) 51/1981/603–624, esp. p. 611.
403 v. F. Sezgin, op. cit. vol. 6, pp. 173-175.
404 ibid, p. 142.
405 ibid pp. 140-143.
408 Catalogus codicum astrologorum graecorum, vol. 5, part 3, Brussels 1904, pp. 7-64.
409 v. Anne Tihon, L’astronomie byzantine, op. cit. p. 612; idem, Tables islamiques à Byzance, in: Byzantion (Brussels) 60/1990/401-425, esp. pp. 405-413.
411 ibid, p. 282.
to an inscription engraved on the back, the instrument, preserved in the Museo dell’Età Cristiana in Brescia, is supposed to have been made for a consul of Persian origin by the name of Sergios. It can be considered as certain that the Byzantines used the astrolabe for the observation of celestial constellations in the 11th century, but because of certain features we should be reluctant in calling this instrument [157] “Byzantine”. Firstly, the fixed star λιγξα (Vega) is represented in the Arabic manner in the form of a bird (an-nasr al-waqi’ = the descending eagle), which was known in the West from the 10th century. Secondly, the latitude of Byzantium (= Constantinople) being indicated as 41° on the disc casts suspicion on the date of the astrolabe. That is because the latitude of Byzantium was registered at 43° in the Ptolemaic geography and 45° with the early Arabic geographers and corrected to 41° only towards the end of the 13th century (the modern value is 41°02’). Thirdly, on the back of the mater a quadruple tangent quadrant is engraved which overlaps the scale on the rim, thus creating the impression that it was added by a later hand, especially in view of the fact that the tangent function, known since 3rd/9th c., begins to appear in the tangent quadrants on the back of astrolabes only from the first half of the 11th century. That the names of the fixed stars correspond to those of the Almagest rather than Arabic does not provide a clue to the age of the astrolabe. The Byzantines has been familiar with the Almagest and its content for a long time. However, the precession value of 1 for 66 years on which the positions of the fourteen stars on the rete are based is Arab-Islamic, not Greek. On the whole the astrolabe is Arab-Islamic in its style and its individual elements, only the language of the engraved names and other inscriptions is “Byzantine”. Thus it reflects the heterogeneous and anachronistic character of the contemporary Byzantine astronomical writings.

After a fairly successful introduction of Arabic language-based astronomy in Byzantium in the course of the 11th and the 12th centuries, the Latin crusade kingdom in Constantinople (1204-1261) not only interrupted any further development, but it also obliterated the body of writings already accomplished at that time. Yet it did not take long until around the turn of the 13th to the 14th century new interest in Arabic-Persian science manifested itself. This time the route to Constantinople came from the east. Immediately after the conquest of Baghdad in the year 656/1258, Hülegü, the grandson of Cengiz Hân, settled in the city of Maragha, roughly 30 km to the south-east of Lake Urmia, and had a grand observatory built under the direction of the polymath Naṣīraddīn al-Fārābī which was furnished with special observation structures (infra II, 28 ff). At the time of the Mongols, Maragha had a significant Christian population segment and maintained busy traffic with the city of Trebizond (Trabzon) on the Black Sea (still under Byzantine rule) and with Constantinople via Trebizond. The interchange with these cities increased when Abaqa Hân, the successor of Hülegü, made Tabrız his capital in the year 663/1265. Tabrız developed into an important centre of sciences when the universal scholar Raşīdaddin Faḍlallāh at-Ṭabīb (d.718/1318, supra, pp. 58, 61) was grand vizier there under the Ilkhāns Gāzān (694/1295-703/1304) and


414 Paul Kunitzsch and Tim Smart, Short guide to modern star names and their derivations, Wiesbaden 1986, pp. 43-44.

Ölgeitü (703/1304-716/1316). Raşidaddin, one of the foremost figures in cultural history, not only became a legend of his times, but personally contributed much in making Tabriz a metropolis and a centre of trade and sciences in which scholars from the East and West were to find a home and representatives of diverse cultures a meeting place. His surviving works convey a vivid [158] picture of the cultural and scientific life in the city.

About the quarter of the city called Rab'-i Raşid or Şahristān-i Raşid that Raşidaddin himself had built, the deed of foundation, which recent research has made known, provides detailed information. The Austrian Orientalist Karl Jahn who, from the 1940s, devoted himself entirely to research into the life and work of Raşidaddin, reports on this document, inter alia: “Thus it follows from this document that the maintenance of the Rab'-i Raşid was secured through the income of various pious foundations which Raşid al-Din had established in Iran and also in Anatolia. But of particular interest is the information about the organisation of the Raşid quarter. According to it, there lived and worked for payment under the supervision of the endowment administration, a large number of artists and artisans, who belonged to all kind of nations, lived and worked for remuneration under the supervision of the foundation council. Aside from a large number of Turks, most of them were either Greek, Georgian, Armenian, Indian, Russian, African and some belonged to still other nations…” The teaching and research institutions had “6000-7000 students from all parts of the Ilkhanid empire studying at public expense, and more than 400 scholars who lived in their own quarters and were in the position to devote themselves to teaching and research unburdened by the troubles of everyday life.”

Further references to the important role of the city of Tabriz in trade and sciences contributed to by Raşidaddin are found in his correspondence with important people of the Islamic and non-Islamic world. We learn from it that in the Rab'-i Raşid he had designated quarters for the various ethnic groups and that he had charged his son Ǧalāladdin, who was governor of a region in Asia Minor, with persuading forty or so Greek families to settle in the district destined for the Byzantines. One discovers further that Constantinople and Venice used to pay tributes to the Ilkphants which Raşidaddin used for the alimentation of the students.

A further testimony to the importance of Tabriz at that time was discovered by Z. V. Togan in the middle of the previous century in the scientific “Questions and Answers” (al-As’ila wa-l-ağwiba) from the correspondence of Raşidaddin. These shed light the close contacts— to an extent which had not hitherto been known— in the field of science between Byzantium and the empire of the Ilkphants. Thus a Byzantine philosopher and physician in the service of Raşidaddin translated his answers to questions of the Basileus (probably Andronikos II Palaiologos, r. 1282-1328) from the Persian into Greek. He also took pains to give the emperor an idea of Raşidaddin’s extraordinary rank in the sciences by stating that “Plato, Aristotle and the other great [Greek] philosophers, if they lived today, 417 ibid, p. 211.
419 Mukātabāt-i Raşīdī, op. cit. p. 319; Z. V. Togan, op. cit., p. 2*.

would be proud to be counted amongst his disciples.”

The “Questions and Answers”, preserved in an Arabic and a Persian version, are predominantly of philosophical, theological and medical content. The Persian redaction was published in facsimile in 1966 with a brief study by Z. V. Togan. No in-depth study of the correspondence is known to me.

Since the attempt by H. Usener (supra p. 154), recent research in the history of Byzantine sciences has concentrated mostly on the fields of astronomy and astrology. The studies from the second half of the 20th century have informed us, above all, about the vogue of translations of astronomical works from the Persian that occurred in the first half of the 14th century. Many of the translated works have meanwhile been edited or examined.

In 1947, George Sarton called the translation movement from the Persian to the Greek “Persian renaissance”, which could also be called “Arabic renaissance”. Karl Krumbacher saw in it “one of the most remarkable examples of literary retro-movement”, and concluded that only through Arabic-Persian mediation had the Greeks come to know the wisdom of their own ancestors. Joseph Mogenet speaks of a kind of renaissance in the field of science during the 13th and the 14th centuries in which the contacts with the Arabic-Persian sciences were of great importance.

The hitherto known astronomical works of the Byzantines,—whose authors built upon the works translated from the Persian with their tables, descriptions of astrolabes etc.—actually reflect more than merely a literary revival movement as held by Krumbacher. However, it is conspicuous that none of the works mentioned, with the exception of the anonymous manuscript discovered by Neugebauer in the Vatican, refers to the new non-Ptolemaic planetary models discussed by Persian and Arabic astronomers in the second half of the 13th century and later. It has long since been proved (supra p. 53 ff) that some of these new planetary theories reached eastern Europe in the first half of the 15th century at the latest and came to be known to Copernicus. The verdict that the Byzantine side showed a lack of criticism and of deeper understanding of Arabic-Islamic astronomy and these shortcomings my be the true reason why Arabic astronomy never established itself firmly amongst the Byzantines. What is more, quite a few Byzantines obstinately held fast to the restoration of Ptolemaic astronomy.

The importance of this third route of reception of Arabic-Islamic sciences was by no means limited to the translation of Persian works into Greek. Personal contacts between Italy, Middle and Eastern Europe and Persia increased the potency of the reception and made it possible for the latest achievements of the eastern Islamic world to reach the West without much delay. Thus, for instance, the advanced rainbow theory of Kamâladdîn al-Fârisî came [160] very probably on this route to the knowledge of Dietrich of Freiberg (infra III, 169 ff) around the first decade

\[410\] Raşidaddin, al-As’ila wa-l-ağwiba, MS Istanbul, Ayasofya 2180, 264b-265a; Z. V. Togan, İlhânlarla Bizans arasindaki kültür münasebetlerine ait bir vesika, op. cit. p. 5.


\[412\] G. Sarton, Introduction ... op. cit. vol. 3, part 1, p. 63.

\[413\] Geschichte der byzantinischen Litteratur, op. cit. vol. 1, p. 622.

\[414\] L’influence de l’astronomie arabe à Byzance du IXe au XIVe siècle, op. cit. p. 54.

\[415\] V. F. Sezgin, op. cit. vol. 6, p. 56.


of the 14th century. We can also imagine that the *Kitāb as-Sākî al-qattā‘* by Naṣīraddīn at-Ṭūsî (d. 672/1274) in which he established trigonometry as an independent discipline reached Europe on this route where it gave rise to the *De triangulis omnimodis* of Johannes Regiomontanus (1436-1476) (infra III, 135 ff.). Naṣīraddīn at-Ṭūsî spent the last sixteen years of his life in Maragha, where he led the newly founded observatory, and both Maragha and Tabriz were still frequently visited by Byzantine and other Christian travellers to Asia in the 14th century. In this connection it is illuminating that an original celestial globe from the Maragha observatory was brought to Europe quite early and was kept in Dresden from 1562 (infra II, 52). With our assumption that Naṣīraddīn’s trigonometry book reached the West via Byzantium we do not necessarily mean to imply that it was already translated there. From when Constantinople was threatened and ultimately conquered by the Ottomans, new paths opened up with branches leading to Rome, northern Italy, eastern and central Europe. Books in the original and in translations as well as instruments and maps were transported along these routes, but most notably a spirit of hostility against Islam on the one hand and the idea of reinstatement of the hegemony of the old Greek sciences on the other. The most notorious character amongst these zealots was Cardinal Bessarion, the former patriarch of Constantinople. During his travels across Europe he also met G. Peuerbach and J. Regiomontanus in Vienna and instigated the latter to revise Ptolemy’s *Almagest*. The fact that this revision predominantly conveys the achievements of Arab astronomers shows us that Bessarion tried in vain to turn back the wheel of the history of science.\(^{428}\)

**Conclusion**

At first a short introduction was envisaged in order to give the user of the present Catalogue an overall idea, based on the current research, of the position of Arabic-Islamic sciences in the universal history of sciences. While attempting this, I was conscious that such an undertaking is connected with all sorts of pitfalls. On the one hand, the research on the subject, despite a relatively long development, is still at such an early stage that one could believe to be able to make a relatively adequate presentation on the basis of the results achieved so far that are within one’s grasp. On the other hand, what has been achieved by research until now is so voluminous that with a first attempt one runs the risk of being able to grasp and transmit only a part. Added to this there are the difficulties connected with the selection of the topics and the problems to be included. Moreover, two conflicting feelings accompanied me from the beginning of the attempt. One of them states that the insights gained so far cannot be dealt with in the scope of a brief introduction, the second consists of the fear that through a more detailed treatment of this theme the further revision of the volumes on geography and literature of my *Geschichte des arabischen Schriftums* prepared approximately fifteen years ago and ready in rough copy would suffer another delay. Therefore I gave up a detailed discussion of the process of assimilation of Arabic-Islamic sciences in the Occident beyond the 13th century which would have allowed me an exhaustive comparison between the two cultures in respect of their basic procedures or basic values of scientific endeavours like the art of experimenting, continuous practical observation for long periods in astronomy [161], the importance of criticism, the custom of naming sources precisely, the acknowledgement of the achievements made by predecessors, the concept of the law of evolution and other topics. These aspects are to be dealt with in the third

\(^{428}\) v. F. Sezgin, op. cit., vol. 6, p. 58.
section that follows, wherein the question is posed about the end of creativity in Islam.

Through the conquest of a substantial part of the region of the Mediterranean and of Persia in the first half of the first century of Islam (7th c. AD), the Muslims were able to bring most of the important cultural centres under their rule. One cannot rate highly enough the great coincidence, which is significant from the viewpoint of history of science, that the carriers of culture of those times, whether Christians, Jews, Sabaeans or Zoroastrians, and regardless of whether they were converted or not, could live together with the conquerors and continue their scientific work, and were even encouraged by their new rulers in such work. Largely on the basis of this harmonious co-existence of people belonging to different cultures and religions, there arose in the Islamic world a teacher-pupil-relationship the like of which was unknown in the European Middle Ages. It resulted in fast and thorough learning, prevented plagiarism, and was for centuries one of the most important characteristics of Islamic scholarship. That the Latin world in its process of reception and assimilation lacked this strength of the Arabic-Islamic world until the beginning of the 16th century was perhaps first pointed out by Raymond Mercier.\(^{429}\)

In the 2nd/8th century we already encounter a fully developed Arabic philology that could provide the necessary tools for the formation or diversification of new disciplines. Without the interplay with a well developed philology the well known perfection and self confidence we know from the translation of Greek works into Arabic from the first half of the 3rd/9th century would have been impossible.

It is one of the most amazing features of the history of science that in chemistry-alchemy after just a single century the phase of reception and assimilation was already over and creativity could begin.

The process of reception and assimilation in most of the other disciplines of the natural sciences had advanced so far towards the end of the 2nd/8th century that they also stood on the threshold of creativity. The qualitatively high and quantitatively broad development of the Arts went hand in hand. Such an upward swing would certainly have been inconceivable had Islam not, as Franz Rosenthal stressed in another context “from the very beginning, emphasised the role of knowledge (‘ilm) as the main driving force of religious life and thus of entire human life” (supra p. 5). But the quick appropriation of foreign knowledge systems and their further elaboration has also substantially to do with the fact that persons belonging to the older cultures could feel accepted by the Muslims and could feel valued from the beginning.

As far as we can judge from the results of research to date, the creativity seems to have begun in the fields of the natural sciences and the exact sciences around the middle of the 3rd/9th century – in individual cases even earlier – and the process of reception and assimilation seems to have been completed towards the end of the century. Creativity continued in all fields with an intensity that can be traced, although it was not always linear, and continued even with the establishment of new fields of sciences until the 15th century – in individual cases also up to the end of the 16th century.

\[^{162}\] In an early phase of the research into the history of the Arabic-Islamic sciences, there developed the habit of speaking of a “golden period” of these sciences which was said to have ended as early as in the first half of the 5th/11th century. Together with this notion, another idea became current according to which a period of stagnation in Arabic-Islamic sciences began with the overthrow of the Abbasid empire by the Mongols in the year 656/1258. Although both the ideas are not confirmed by the latest research, they are still mentioned now as be-

fore. In reality, the 13th, the 14th and even the 15th centuries turn out to be an era of numerous discoveries, of inventions and of the establishment of new disciplines of knowledge in Arabic-Islamic sciences.

When the sciences in the Arabic-Islamic world were still in the first phase of their upward movement, they began to spread from Spain to other parts of Europe in the second half of the 4th/10th century. The designation of this current, lasting several centuries, as reception and assimilation of Arabic sciences in Europe came into use in the second half of the 20th century. Heinrich Schipperges, who could be considered the father of this designation, used it almost with the same meaning as the term “Arabism”. The fluctuating assessment of the value of Arabic-Islamic sciences for Europe, as can be traced in its contradiction through the centuries, continues still. We cannot say that research has not advanced far enough to give the historian of science enough relevant material for a more objective view of the factual position; but the anti-Arabism that already began towards the end of the 13th century is still felt and is again strengthened through the Euro-centric attitude of the last three hundred years. We owe to Heinrich Schipperges an instructive description of the anti-Arabism itself, which is distinguished from the term Arabic studies, as a “manifestation that has greatly influenced the centuries and is still exercising influence without which we will not understand the structure of the modern world.”

In several studies, Schipperges attempted to approximately demarcate the various stages of Arabism – he sees its end after 1700 without excluding its continued effect in the field of medicine up to the 19th century. At this place we may mention that Schipperges, while doing research in Spanish libraries in 1967, discovered among 200 Latin manuscripts no less than 60 titles by hardly known Spanish physicians and could convince himself that the “Spanish Arabists” of the 13th to the 17th centuries had “not only had an influence on the Iberian schools but beyond that on the European universities as well.” In the course of another research trip through Spanish libraries he found “in the Spanish region until far into the 17th and the 18th centuries a Galenism that oriented itself towards Avicenna.”

Deviating from Schipperges’ finely differentiated stages of “European Arabism”, when we now search, in a broader periodisation, the beginnings of that stage in which creativity could be noticed in Europe as a consequence of the sufficiently long reception and assimilation of Arabic-Islamic sciences, then we are led to the beginning of the 16th century. I am aware that the mere mention of such a statement will agitate some people. However, research into the history of Arabic-Islamic sciences has advanced so much since the commendable pioneering work by the indefatigable scholars Jean-Jacques Sédillot, Louis-Amelie Sédillot, Joseph-Toussaint Reinaud, Franz Woepcke, Michael Jan de Goeje, Eilhard Wiedemann, Carl Schoy, Heinrich Suter and others from the 19th century and the first third of the 20th century, and this research has furnished us with so much convincing material that we – true to our responsibility

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432 ibid, p. 5.
433 v. e.g. Handschriftenstudien in spanischen Bibliotheken zum Arabismus des lateinischen Mittelalters, in: Sudhoffs Archiv (Wiesbaden) 52/1968/3-29, esp. pp. 27-28; idem, Arabische Medizin im Mittelalter, op. cit., p. 150.
434 Handschriftenstudien, op. cit., p. 22.
435 ibid, p. 27.
must make every attempt to bring about a revision of the prevailing assessment of our subject in the historiography of science.

With our view of placing the onset of creativity in Europe at the beginning of the 16th century, we of course deviate from the common path taken in the historiography of sciences, which enumerates a series of achievements as the accomplishments of the so-called “Early Renaissance,” to which belong the origin of universities in Europe, the application of mathematics to problems of natural sciences by Roger Bacon (ca. 1219- ca.1292), the first correct explanation for the formation of the rainbow by Dietrich of Freiberg (ca.1250-ca.1310), or also the achievements ascribed to Levi ben Gerson (1288-1344) of the invention of the camera obscura, of the spherical sine theorem and of the proof for the postulate of parallels, as well as the establishment of trigonometry as an independent discipline by Johannes Regiomontanus (1436-1476).

As far as the foundation of universities is concerned, it is not surprising that the oldest of them originated in the first third of the 13th century in centres of the assimilation of Arabic-Islamic sciences like Naples (1224), Padua (1222), Paris (1219), Toulouse (1229), Montpellier (1239) or Palencia (1212).437 In his study, written from the perspective of a non-Arabist, Herbert Grundmann438 came to the conclusion that “the universities arose spontaneously, without a conscious model, spontaneously, out of the urge for knowledge. Even if there had been no Greek, Roman or Byzantine model, – why did nobody ask about the Arab model, about that mediator culture of the Middle Ages, the genuine catalyst that secured and actualised the heritage of Antiquity for the universities?” Of Arab models Schipperges441 mentions the al-Madrasa an-Nizamiya, founded in 457/1065 in Baghdad: “We have detailed plans of similar school buildings. They were laid out as a square with a garden, [164] contained lecture halls and conference rooms, a central library with all technical divisions, depots and magazines … The appointment of professors was done by ministerial order. Inaugural lectures took place in the presence of high dignitaries followed by a disputation in honor of the newly appointed professor, often also in the presence of the Caliph. Afterwards the new docent gave an installation banquet. In the teaching itself, it was these professors who had to organize the typical scholastic discussions, so-called repetitors functioned as assistants. It was the Nizamîyya in Baghdad once again which introduced, since the middle of the 11th century, a general plan into Islamic institutions of higher learning.”

“The reflection of this important school foundation can be observed quite exactly in the case of a later Baghdad academy, the famous Madrasa Mustanširiyya. It was founded in 1227 by Caliph al-Mustansîr. The building, situated on the left bank of the Tigris, was completed in 1232 and consisted of four large complexes, among them a special building for the teaching of medicine, the Occidental Middle Ages.”439 Schipperges440 commented on this as follows: “We can agree with Grundmann only to a limited sense when he speaks of universities arising without a conscious model, spontaneously, out of the urge for knowledge. Even if there had been no Greek, Roman or Byzantine model, – why did nobody ask about the Arab model, about that mediator culture of the Middle Ages, the genuine catalyst that secured and actualised the heritage of Antiquity for the universities?”

439 H. Grundmann, Vom Ursprung der Universität, op. cit., p. 17.
440 Einflüsse arabischer Wissenschaft, op. cit., p. 211.
pharmacy and natural sciences. Annexed to it were a hospital, a central kitchen, baths and de-
pots” (cf. the chapter on architecture, vol. V, 65 ff.).

“Among the subjects of instruction the strong ac-
cent on the exact sciences is noticeable: besides
religion and languages, as subjects of instruc-
tion, mathematics and medicine are especially
mentioned; and enumerated individually are
geometry, nature studies, pharmacy and hygiene.
The importance that was attributed to such a
school can be seen from the fact that, although
it was partially destroyed at the time of the inva-
sion by the Mongols in 1258, it was soon rebuilt
and reorganised by the conquerors themselves”.

Schipperges 442 continues: “There can be no
doubt that such renowned academies became
known in the Occident in their outer forms also,
given the stormy reception of teaching materi-
al since the middle of the 12th century and the
lively west-east peregrination of the young sci-
centists.”

In Europe, there were various ways and paths
to learn about the universities of the Arabic-
Islamic world. However, for the appropriati-
on of this institution, receptivity and maturi-
ty were required that had been achieved in the
Occidental-Christian world through the recep-
tion and assimilation of Arabic-Islamic sciences.
We find the most convincing clue for this in the
university founded by Emperor Frederick II in
Naples in 1224. It was the first state universi-
ty443 in Europe and thus corresponded with its
predecessor an-Nizāmiya in Baghdad and many
others in the Islamic area. That Frederick II was
in close contact with the Arabic-Islamic world
and an admirer of and adherent to its culture and
science is widely known (supra p. 148 ff).

The second point mentioned above refers to
Roger Bacon. Not only in his case the historio-
graphy of science is burdened with long outda-
ted ideas originating under Euro-centric views.
The designation of Bacon as the founder of the
application of mathematics to problems of natu-nal sciences is conferred at the cost of his Arab
predecessors, among them Ibn al-Haitam.444 R.
Bacon established relationships to Arab “models
without reaching up to them when he made his
general observations concerning the experiment
[165] as the basis for research in the natural sci-
ences. However, he did not invent this method,
but only presented it systematically, although
in a somewhat different interpretation than the
Arabs did. He is not the creator of the experi-
mental method just as Bacon of Verulam [1561-
1626] is not the creator of the inductive method,
even though the English would like to ascribe
both to their compatriots.”445 Towards the end of
the 19th century P. Mandonnet446 remarked that
Roger Bacon had taken all his scientific ideas
from the Arabs.

“Despite his critical attitude, Roger Bacon was
decisively influenced by the Arab thinkers, par-
ticularly by Averroes and Avencebrol. He was
unfairly made the forerunner of the modern sci-
centific methods; Roger’s indecision may have in-
fluenced this assessment rather than an indepen-
dent intellectual attitude” wrote H. Schipperges
in 1961. 447

442 Einflüsse arabischer Wissenschaften, op. cit., p. 209.
443 H. Grundmann, Vom Ursprung der Universität, op.
444 v. E. Wiedemann, Roger Bacon und seine Verdien-
ste um die Optik, in: Roger Bacon Essays, contributed by
various authors, Oxford 1914, pp. 185-203, esp. pp. 186-
445 E. Wiedemann, Die Naturwissenschaften bei den
orientalischen Völkern, in: Erlanger Aufsätze aus ernster
Zeit, Erlangen 1917, pp. 49-58, esp. p. 58 (reprint in: E.
Wiedemann, Gesammelte Schriften, vol. 2, pp. 853-862,
esp. p. 862 and in: Historiography and Classification of
446 Les idées cosmographiques d’Albert le Grand et de
S. Thomas d’Aquin et la découverte de l’Amérique, in: Re-
vue Thomiste (Paris) 1/1893/46-64, 200-221; F. Sezgin,
447 Ideologie und Historiographie des Arabismus, op.
cit., p. 11.
On the question of the excellent theory of the rainbow which became known in Europe through Dietrich von Freiberg in the first decade of the 14th century, but which originates in reality from the Arabic-Islamic world, I restrict myself to a reference to the relevant remarks on the subject in this introduction (supra p. 56 ff.) and in the chapter on optics in our Catalogue (infra III, 169 ff.).

As far as the achievements ascribed to Levi ben Gerson (1288-1344) are concerned (supra p. 163), we may mention that in the case of the camera obscura he followed Ibn al-Ha˚am (infra, the chapter on optics, III, 184 ff.). As regards the spherical sine theorem, he must have used sources which brought him in contact with his Arabic predecessors (infra III, 135 ff.) and with his attempt to prove the postulate of the parallels (infra III, 126 ff.) that he undertook as the first person in Europe, he was once again dependent on his predecessor Ibn al-Ha˚am.

In the case of the alleged establishment of trigonometry as an independent discipline through Johannes Regiomontanus, we point out that he had Nasiraddn afl-nas’s predecessor (supra p. 160).

If we leave aside the advance made by Gutenberg around 1450 with the development of book printing, then there remains the decision by Copernicus in favour of the heliocentric system as another sign of Occidental creativity. The heliocentric system had already been thought of by Aristarchus (3rd c. BC) and Seleukus (2nd c. BC) and it had been also taken into account by Arabic astronomers and philosophers who, however, partly could not decide in the affirmative and were partly content with the rotation of the Earth (supra p. 20). At all events one should not forget that the Copernican system, in the words of Carlo Alfonso Nallino, “remained for longer than a century a purely philosophical question – without interest for observational astronomy which could not have brought to its support a single decisive or important reason”. Also the most important European astronomer, Tycho Brahe (1546-1601) could not follow this system. He was content with the notion that the upper planets were satellites of the Sun and that the Sun together with the Moon circled the Earth. We have already mentioned that Copernicus (1473-1543) stood in a tradition of dependence on Arab astronomers and appropriated their planetary models. In observational astronomy, progress became possible only when, in the second half of the 16th century, observatories began to be placed in the service of astronomy, a feature that had been common in the Arabic-Islamic world already for six hundred years. It was Tycho Brahe who achieved the first known advance with his discovery of the third inequality or variation of the Moon. But we may mention in passing that about half of this variation was already included in the equation of the anomaly of the Moon by Arab astronomers.

Of course, the progress made by Copernicus in theoretical and by Tycho Brahe in observational astronomy does not mean that the era of dependence on Arabic-Islamic scholars had come to an end. Even Johannes Kepler (1571-1630) was still dependent on his Arabic-Islamic predecessors. From the field of astronomy we may mention that the deductive explanation given by the Andalus-Arab scholar az-Zarqâi (end of the 5th/11th c.) of the orbit of Mercury as an oval resembles the explanation of the orbit of Mars.

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453 C. A. Nallino, op. cit., column 520a; R. Wolf, Geschichte der Astronomie, Munich 1877, pp. 54-55.
by Kepler.\textsuperscript{454} Kepler also showed great interest in az-Zarqâl’s value of the Sun’s apogee, the point of the Sun’s greatest distance from Earth (supra p. 34). Copernicus also knew of the model of the Sun developed by az-Zarqâl. He described it as “a nice invention” and used it in his own theory.\textsuperscript{455}

The dependence of European scholars on the accomplishments of the Arabic-Islamic area, still discernable in the second half of the 16th century, is not limited to astronomy, but is true of almost all fields of science. For instance, the Europeans’ acquaintance with anthropogeography, which had been cultivated in the Arabic-Islamic world and which was already at its peak in the 4th/10th century, commenced rather late. It came about in the first half of the 16th century through the description of Africa known by the name of Leo Africanus, which we have mentioned above (p. 77). The anthropogeographical contents of Idrisi’s \textit{Geography} did not appeal to Europeans until late. Leaving aside the after-effects through its maps that could already be discerned in the 13th century, the \textit{Geography} itself became known through the Latin translation of an extract in 1619. Nonetheless we can follow the impact of al-Idrisi and Leo Africanus up to the 19th century. In mathematical geogrophy and cartography also, a strong European dependence on Arabic-Islamic predecessors was noticeable until the end of the 18th century and beyond. However, in the 16th century in which creativity began to make itself felt in many fields, anti-Arabism continued to show itself along with Arabism. Now it took the form of a denial of the past and of an immoderate viliification of the Arabs and even the Greeks. Thus Paracelsus (ca. 1493-1541) writes: “There is no need for the fatherland to emulate the thoughts and customs of the Arabs or the Greeks, [\textsuperscript{167}] on the contrary, that would be an error and strange presumption.”\textsuperscript{456} Agrippa of Nettesheim (1486-1535) is more specific: “Afterwards many barbarian philosophers arose and wrote about medicine for which the Arabs have become so famous that one has taken them for the inventors of the art; and they could easily have claimed that, had they not used so many Latin and Greek names and words and had they not thus betrayed themselves. Therefore the books by Avicenna, Rhazis and Averroes have been invested with the same authority as those of Hippocrates and Galen, and they have received so much credit that whosoever attempts to cure without them, it could have been easily said about him that he ruined the common weal.”\textsuperscript{457} There was no dearth of defenders of Arabism against such attacks. One of the main defenders of those days was Andreas Alpagus (d. ca. 1520) who, after a stay of about 30 years in Arabic countries, returned to Padua, where he was active as an Arabist, correcting older Latin translations and translating further books from the Arabic, among them the important commentary by Ibn an-Nafis (d. 687/1288) on the anatomy of Ibn Sinâ. The discovery of the minor blood circulation by Ibn an-Nafis that is documented in this work found, through the translation, entry into the work of the Spanish physician Miguel Servet (1553) because of which Servet was long considered by the European physicians as the discoverer of minor blood circulation (supra p. 50).

Neither the rejection nor the defense of Arabic-Islamic sciences came to an end with the close of the 16th century, but both continue till today. Islamic culture has on its side no less a person than Johann Wolfgang von Goethe who expressed his admiration explicitly: “If we want to participate in these creations of the most excellent minds, then we must orientalise ourselves, the Orient will not come over to us. And alt-

\textsuperscript{454} V. F. Sezgin, op. cit., vol. 6, p. 44.


\textsuperscript{456} V. H. Schipperges, \textit{Ideologie und Historiographie des Arabismus}, op. cit., p. 23

\textsuperscript{457} Ibid.
hough translations are highly laudable to entice us, to introduce us, still it is evident from all that has been said before that in this literature, language as language plays the leading role. Who would not want to acquaint himself with these treasures at the source!"  