Science and Technology in Islam

I

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Türkiye Bilimler Akademisi
Turkish Academy of Sciences

Science and Technology in Islam
Prof. Dr. Fuat Sezgin

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BAYKAR

TURKISH TECHNOLOGY TEAM

SCIENCE AND TECHNOLOGY IN ISLAM

VOLUME I

Introduction to the history of Arabic-Islamic sciences

by

Fuat Sezgin

Translated by

Renate Sarma

and

Sreeramula Rajeswara Sarma

2010

Institut für Geschichte der Arabisch–Islamischen Wissenschaften

an der Johann Wolfgang Goethe-Universität

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Turkish Academy of Sciences

PREFACE

Civilization is the shared legacy of all humankind. Europe has attempted to convince the rest of the world that all societies experienced a thousand years of darkness during the Middle Ages, not just itself. However, it has only recently been recognized that this perspective is incompatible with the truth. The Islamic world experienced a period of enlightenment during a time when Europe was behind in science and intellect, and this enlightenment ultimately aided in Europe's own intellectual growth and progress.

The research and scholarship of Islamic scholars during the Middle Ages had a lasting impact on both the period in which they lived and on subsequent ages. Their work served as a catalyst for the Renaissance and Reform movements in Europe and contributed significantly to the scientific advancements of the modern period in Europe. This has led to a shift in perspective away from a Eurocentric view of scientific development and progress, as European scientists increasingly recognize the importance of the contributions made by the Islamic world.

Professor Fuat Sezgin, who passed away in 2018, was a renowned scholar who dedicated his career to exploring the role and significance of Islamic civilization in the development of the West and to highlighting the contributions of Islamic scholars to scientific and technological progress in Europe. He disseminated his research through various scientific works, including the book "Science and Technique in Islam," which was written in German and later translated into Turkish under the leadership of TÜBA. Professor Sezgin's lifelong dream was realized in 2008 with the opening of the "History of Islamic Science and Technology Museum" in Istanbul's Gülhane Park, which showcases the achievements of Islamic scholars through a collection of approximately 600 tools, device replicas, and models.

We are proud that Professor Fuat Sezgin's book "Science and Technique in Islam" has been published in multiple languages, including Turkish, English, German, French, Russian, and Kyrgyz. We are grateful to those who contributed to the publication of these works, including the valuable scientists who participated in the project and the organizations BAYKAR and the Turkish Technology Team (T3) who provided sponsorship.

We commemorate Professor Fuat Sezgin with mercy.

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PREFACE

At the time of the Romantic movement, when, under the impact of the newly established periodization that did not do justice to historical facts, there prevailed a biased view of the Renaissance and a negation of the achievements of the Middle Ages, Jean-Jacques Sédillot and his son Louis-Amélie published in 1834 the French translation of the manuscript preserved in Paris of the monumental Arabic work by Abu l-Ḥasan al-Marrākušī (7th/13th c) on applied astronomy and astronomical instruments.[1] This was followed ten years later by an admirable study of al-Marrākušī's book by Sédillot junior.[2] No doubt, men like Johann Gottfried Herder (1744-1803), Johann Wolfgang von Goethe (1749-1832), Kurt Sprengel (1766-1833), or Alexander von Humboldt (1769-1859), had previously given due credit — in the spirit of Humanism — to the Muslims or Arabs for their achievements in the history of science. Yet for decades Sédillot and his son fought for a more just approach by the scholarly world towards the achievements of the Arabic-Islamic world, even though this was resented by their academic colleagues and by the French Academy.

By a happy coincidence, the battle fought by the two Sédillots was supported by the work of the indefatigable scholar Joseph-Toussaint Reinaud (1795-1867). Produced with no less creativity and conviction, Reinaud's oeuvre dealt with the areas of geography,[3] Islamic archaeology[4] and the technology of warfare.[5] In one of his publications, he gave meaningful expression to the concept of the unity of the history of science in the following words:[6] "Chance does not play such an important role in the progress of the technical sciences and the arts. In all its discoveries, humanity moves at an even pace, step by step, not by leaps and bounds. It does not always march ahead with the same speed, but its [**viii**] progress is continuous. Man

[1] *Traité des instruments astronomiques des Arabes*, 2 vols, Paris 1834-1835 (reprint Frankfurt 1998, Islamic Mathematics and Astronomy, vol. 41).

[2] *Mémoire sur les instruments astronomiques des Arabes*, Paris 1844 (reprint in: Islamic Mathematics and Astronomy, vol. 42, pp. 45-312).

[3] Among Reinaud's numerous publications in this area, his *Introduction générale à la géographie des Orientaux* had an especial impact on the historiography of geography; it appeared as the introductory volume to his translation of the geographical work of Abu l-Fidā' (*Géographie d'Aboulféda*, 2 vols., Paris 1848, 1883; reprint Frankfurt 1998 as *Islamic Geography*, vols. 277-278).

[4] *Monumens arabes, persans et turcs du cabinet de M. le Duc de Blacas*, 2 vols., Paris 1828.

[5] In this area, mention may be made of the study produced in collaboration with Ildephonse Favé: *Du feu grégeois. Des feux de guerre et des origines de la poudre à canon*, Paris 1845 (reprint Frankfurt 2002, Natural Sciences in Islam, vol. 87).

[6] J.-T. Reinaud and I. Favé, *Du feu grégeois*, op. cit., p. 2.

does not invent, he deduces. If we take any area of human knowledge, its history, that is to say the history of its progress, should form an uninterrupted chain; the factual history provides us with parts of this chain, and our research must consist in finding the lost links so that we can join one part with the other."

While Ernest Renan (1823-1892) propounded in his *Averroès et l'Averroïsme*, which appeared in 1853, an entirely new outlook on the reception of Arabic philosophy in Europe — an outlook that is surprising for the historian of science —, an extra-ordinarily gifted young German scholar, who studied in Paris with Alexander von Humboldt's support, published between 1851 and 1864 some forty studies on Arabic mathematics. He was Franz Woepcke (1826-1864), who unfortunately died too young at the age of 38. His works written in French, some of which remain unsurpassed even today, constitute a solid foundation for the historiography of Arabic-Islamic mathematics of our times. Particularly impressive was his dissertation *L'algèbre d'Omar Alkhayyâmî*, which appeared in 1851. Here Woepcke establishes that the book on algebra by the philosopher, astronomer and mathematician 'Umar al-Haiyam from the second half of the 5th/11th century contains a systematic treatment of cubic equations. This conclusion surprised the contemporary mathematicians all the more because they remembered the sweeping judgment by Jean-Étienne Montucla,[7] who was considered an authority on the history of mathematics, to the effect that the Arabs did not go beyond quadratic equations in algebra. Thus the intensive and extensive research and studies of the great Arabists J.-J. Sédillot, L.-A. Sédillot, J.-T. Reinaud and F. Woepcke opened up remarkable and hitherto unanticipated perspectives for the future research on the role of the Arabic-Islamic scholars in the universal history of science.

The powerful impulses given by these four scholars were not without consequences, when in 1876 Eilhard Wiedemann (1852-1928) began his studies, which he was to continue for half a century. Wiedemann was a physicist and the majority of his publications are in the field of physics and technology, yet, as time passed, he extended his interest to almost all branches of Arabic-Islamic science. The written output of this indefatigable scholar appeared in more than 200 articles and monographs. His works, later collected in five extensive volumes,[8] were of decisive

[7] *Histoire des mathématiques*, vol. 1, Paris 1758, p. 359 f.

[8] The first two volumes, published by Wolfdietrich Fischer under the title *Aufsätze zur arabischen Wissenschaftsgeschichte* (Hildesheim and New York 1970), contain the 81 articles by Wiedemann which appeared in 'Sitzungsberichte der Physikalisch-medizinischen Sozietät zu Erlangen'. The great majority of his other writings were collected in three volumes as *Gesammelte Schriften zur arabisch-islamischen Wissenschaftsgeschichte* by Dorothea Girke and Dieter Bischoff (Frankfurt: Institut für Geschichte der Arabisch-Islamischen Wissenschaften 1984).

influence on the historiography of natural sciences during the author's life-time as also later on, and will be indispensable for future research.

[ix] Moreover, Wiedemann attracted a large number of pupils and entrusted them with research on important aspects. The work produced by them was as substantial as that of the teacher. This has constituted until now, and will continue to be so in future, the building blocks for the historiography of the natural sciences cultivated in the Arabic-Islamic world.

It is a pleasant duty for me to state that in our efforts to construct and reconstruct instruments, devices and tools which were used, developed, or invented in the Arabic-Islamic world, we have once again Eilhard Wiedemann as the forerunner to be emulated. He reports in several of his writings that he and his assistants reconstructed one or the other instrument. Unfortunately, I was not able to find out more about the fate of his models, beyond the fact that in 1911 the Deutsches Museum in Munich bought five pieces from Wiedemann and the mechanic F. Kelber, who worked with him. The correspondence on the astrolabe, which was among them, shows the difficulties that were encountered at that time, especially in reproducing the letters of the alphabet. Upon the request of the Museum to have these engraved in Arabic, Wiedemann replied thus: "I suggest that the numbers on the astrolabe be chiseled in our script. In Arabic script, they would need to be engraved, which would be expensive and would also mean much trouble for me." We know now that the prototype for Wiedemann's model was an astrolabe by Muḥammad Ibn aṣ-Ṣaffār (420/1029, see vol. II, p. 95), which is now in the possession of the Staatsbibliothek at Berlin. The instrument "was manufactured; the doubtful areas on the limb and on the back remained empty; instead of engraving the legends, appropriately printed papers were pasted on the plates and on the rete."[9]

The instruments and apparatuses, tools and devices which are described in the present Catalogue and are depicted in its illustrations were produced for the purpose of contributing — together with the publications of the Institute for the History of Arabic-Islamic Sciences which was founded in 1982 at the Johann Wolfgang Goethe-University at Frankfurt — towards a revision of the prevailing negative notions about the achievements made over around eight hundred years in the Arabic-Islamic world. While striving for such a revision, we proceed neither in our basic assumptions nor in our actions in a heuristic manner, but believe [x] in the unity of the history of science, thus adhering to the credo formulated by Reinaud and Favé to the effect that the common scientific heritage of mankind grows by continuous steps, though not always in a linear fashion but though with varying

[9] Burkhardt Stautz, *Die Astrolabiensammlungen des Deutschen Museums und des Bayerischen Nationalmuseums*, München 1999, pp. 385-386.

speed. When a particular culture area at a given time takes the lead, or rather, is led to take the scientific heritage further by yet another step, be it large or small, then the historical conditions and the level of progress achieved by the forerunner are the factors that influence the speed and the progress, if any, of the successor. The dominant position of the Greeks is generally acknowledged and appreciated by the historiography of science. Yet, there is still some uncertainty about the question, which Greek scholars do not like to discuss, about the directly or indirectly inherited achievements from the previous and neighboring culture areas which the Greeks drew upon and elaborated further. On this, Otto Neugebauer said as late as in 1932: "Every attempt to connect Greek [science] with pre-Greek [science] encounters strong opposition. The possibility of having to modify the received notion about the Greeks is always unwanted, in spite of all the changes which the received notion underwent from Winkelmann's time onwards by the simple fact that since then, to the 2500 years of 'history', another 2500 years more have been added, and the Greeks are therefore in the middle [of history] and not any more at the beginning."[10]

Here one may mention a fact to which, in my view, enough attention has not been paid so far in the history of science; namely that we can recognize the sources and the forerunners of the Arab-Islamic scholars more easily and more clearly than in the case of other cultures known to us. Indeed Arab scholars were in the habit of quoting their sources with precision and of mentioning their forerunners, in particular the Greeks, with high respect and gratitude. Thus they enable us, for example, to trace the otherwise unknown instruments of the Greeks, or to recover from quotations fragments of Greek writings, which have been lost in the original.

[**xi**] It is true that, since the powerful impetus we owe to J.-J.Sédillot, L.-A. Sédillot, F.-T. Reinaud and F. Woepcke, much has been contributed by the Arabists, who were interested in the history of science, towards modification of the prevalent unfounded notion about the achievements made by the Arabic-Islamic world in

[10] *Zur geometrischen Algebra*, in: Quellen und Studien zur Geschichte der Mathematik, Astronomie und Physik (Berlin) 3/1936/245-259, esp. p. 259. In his innumerable publications, Neugebauer strove to clarify the question about the forerunners to the Greeks in the areas of astronomy and mathematics; see, besides his monumental work *A History of Ancient Mathematical Astronomy* (3 vols., Berlin, Heidelberg, New York 1975), the following publications: *Über griechische Mathematik und ihr Verhältnis zur vorgriechischen*, in: Comptes rendus du Congrès international des mathématiciens (Oslo 1936), Oslo 1937, pp. 157-170; *Über babylonische Mathematik und ihre Stellung zur ägyptischen und griechischen*, in: Atti des XIX Congresso Internazionale degli Orientalisti (Roma 1935), Rome 1938, pp. 64-69; *The Survival of Babylonian Methods in the Exact Sciences of Antiquity and the Middle Ages*, in: Proceedings of the American Philosophical Society 107/1963/528-535; *Babylonische Mathematik und Astronomie und griechische Wissenschaft*, in: 400 Jahre Akademisches Gymnasium Graz. Festschrift, Graz 1973, pp. 108-114.

the intellectual history of humankind. Even so, E. Wiedemann's lament of 1918 unfortunately remains valid: "Again and again we encounter the view that the Arabs have merely preserved for us through translations the knowledge gained from antiquity without, however, adding anything substantially new."[11] The reason is mainly to be seen in the fact that in the historiography of science there prevails a persistent attitude which ignores the approximately 800 year long creative period of the history of science, thereby also already decisively influencing schoolbooks, the basic notions of modern man with regard to the history of science. This judgment holds good not only for the Occident, but in its widest sense also for today's Arabic-Islamic world, where school books are designed according to American or European models.

We hope the future visitors can acquaint themselves either in the Museum here or in exhibitions elsewhere with the instruments and devices of our Museum, which are described in the present Catalogue; we hope that this acquaintance will contribute to the concept of the unity of the history of science, which states that in the period between late antiquity and the European modern age the Arabic-Islamic world was the one most capable of development and the most influential cultural area and was the essential link between the Old World and the emerging Occident.

The introduction in the present first volume of the Catalogue is also to serve as an aid to the hoped-for revision. At first, the introduction was planned as a simple outline in order to provide the user of the Catalogue with some historically helpful information. During the course of writing, it took on the present form because the material to be communicated to the reader was much more than at first envisioned. The presentation appearing under the audacious title *Introduction to the History of Arabic-Islamic Sciences* is an attempt, perhaps the first of its kind, to summarize briefly and in chronological order the relevant conclusions arrived at in research to date, without introducing — just for their sake — the eminent personalities who were responsible for the development. It is an attempt, which may have its validity for some time [**xii**] and, considering the research into Arabic-Islamic natural sciences which is fortunately progressing well today, it may soon hopefully serve as a spring board for an enlargement of this presentation.

In the case of a small portion of our astronomical and medical models, we have depended upon the exhibits in museums without, of course, being able to achieve the perfection of the originals. The largest part of our models are based on illustra-

[11] *Die Naturwissenschaften bei den orientalischen Völkern*, in: Erlanger Aufsätze aus ernster Zeit, Erlangen 1917, pp. 49-58, esp. p. 50 (reprint in: E. Wiedemann, Gesammelte Schriften, vol. 2, pp. 853-862, esp. p. 854).

tions and descriptions in Arabic, Persian, Turkish or Latin sources, either on the basis of the originals or of studies. A certain number of models were produced in our workshop. In the reconstruction of the larger part, we depended on the help of people from outside. In this connection, my sincere thanks are due to Günter Hausen (Frankfurt, Institut für angewandte Physik), Herbert Hassenflug (Frankfurt, Physikalisches Institut), Matthias Heidel (Frankfurt), Werner Freudemann (Frankfurt), Gunnar Gade (Marburg), Professor André Wegener Sleeswyk (Groningen), Dr. Günther Oestmann (Bremen), Dr. Felix Lühning (Bremen), Mahmut Inci (Düsseldorf), Martin Brunold (Abtwil, Schweiz), Eduard Farré (Barcelona), Aiman Muhammad ʿAlī (Cairo), ʿAbdalwahhāb Kāzim (Cairo), ʿAlī Wafāʾ (Cairo) and Kurultay Selvi (Istanbul).

For the preparation of the Catalogue, I owe thanks, besides to my colleague Eckhard Neubauer, to Mr Daniêl Franke who designed the layout, prepared the photos and drawings, independently worked on the chapter on "Antique Objects" (Ch. 13) and who, with his knowledge and critical interest, substantially contributed to the success of the undertaking, as also to my colleague Mr. Lutz Kotthoff, who fabricated many of the models in our workshop, made an inventory of the artifacts and contributed technical drawings as well as descriptions of the instruments. I thank my colleagues Dr. Gesine Yildiz, Dr. Carl Ehrig-Eggert and Norbert Löchter for compiling the indices and bibliographies. Dr. Annette Hagedorn (Berlin) very kindly took up the description of glass and ceramics with oriental designs (Ch. 14). My thanks are also due to UNESCO for the financial support for printing the French version of the Catalogue.

I cannot thank my wife adequately enough, not only for following the various stages of the preparation of the manuscript of the Catalogue and for repeatedly reading the proofs, but above all, for being at my side through all the difficulties while setting up the museum and for giving me encouragement.

Frankfurt, August 2003 Fuat Sezgin

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II

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in collaboration with

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2010

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an der Johann Wolfgang Goethe-Universität

Frankfurt am Main

2023

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2. GEOGRAPHY • 3. NAVIGATION

4. CLOCKS

5. GEOMETRY • 6. OPTICS

2010

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7. MEDICINE • 8. NAVIGATION
9. MINERALOGY

2010

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