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Alparslan Açikgenç

Major Discoveries and Inventions

A well-known *ḥadīth* of the Prophet says that "The ink of the scholar is holier than the blood of the martyr. Acquire knowledge, because he who acquires it in the way of the Lord performs an act of piety; who speaks of it, praises the Lord; who seeks it, adores God; who dispenses instruction in it, bestows alms; and who imparts it to its fitting objects, performs an act of devotion to God" (Jalāl al-Dīn al-Suyūṭī, *al-Jāmiʿal-saghīr*).

Much has been discussed in relation to this tradition, which seems to be stated in particular within the circle of Ḥasan al-Baṣrī in the southern Iraqi urban area; however, even if different specialists of *ḥadīth* argued that this is a weak tradition, it is hard to deny the meaning of these Qurʿānic passages:

> "And He it is Who spread the earth and made in it firm mountains and rivers, and of all fruits He has made in it two kinds; He makes the night cover the day; most surely there are signs in this for a people who reflect" (39:3);
>
> "What! He who is obedient during hours of the night, prostrating himself and standing, takes care of the hereafter and hopes for the mercy of his Lord! Say: Are those who know and those who do not know alike? Only the men of understanding are mindful" (39:9);
>
> "Supremely exalted is therefore Allah, the King, the Truth, and do not make haste with the Quran before its revelation is made complete to you and say: O my Lord! Increase me in knowledge" (20:114)

in which the religious understanding is a gift given by God to the rational mind of human being.

At the beginning of the ʿAbbāsid period, in antithesis to the previous Umayyad Caliphate more rooted in the superiority of Arab clan membership, the equality guaranteed to the *mawālī* stimulated a cultural attitude summarized by the philosopher al-Kindī in this passage: "We ought not to be embarrassed about appreciating the truth and obtaining it wherever it comes from, even if it comes from races distant and nations different from us. Nothing should be dearer to the seeker of truth than the truth itself, and there is no deterioration of the truth nor belittling either of one who speaks it or conveys it" (Peter Adamson, *Al-Kindī*, Oxford University Press, 2007).

An armed fight made possible a cultural renaissance focused on the rediscovery of ancient sources, which enabled and encouraged the coming out of a universal and interdisciplinary culture. The battle, a struggle between the Tang governor of Qucha, the Korean Kao Hsien-Chih, and the Turkish-Khorasanian forces led by Ziyād ibn Ṣāliḥ al-Khuzāʿī, close to the Talas River, was won by Islamic forces. More relevant than military success, however, was the capture of Chinese experts in sericulture and the making of paper, a material known in China for more than a millennium and made using the remains of flax and hemp. This capture allowed Muslims to acquire the technical knowledge needed to produce one of the most crucial tools for the progress of human civilization. So it was that the first paper mill in the Islamic world was built in a very short time in Samarkand, while not until 794–795 was the first paper mill built in the capital Baghdad. The advent of this procedure greatly reduced the cost of books regardless of the subject matter.

The Academies of Antiquity Revived in the Islamic Age: The Translation Movement. The production of paper stimulated a process that had already begun at the beginning of the ʿAbbāsid period under the caliph al-Manṣūr (r. 754–775)—who was supposed to have translated Euclid's *Elements*—and carried on for more than two centuries: the translation of ancient primary sources of knowledge in Greek, Old Persian, Sanskrit, Syriac, and other languages into Arabic. The "House of Wisdom," a scientific institution founded in Baghdad by the caliph al-Maʾmūn (r. 813–833) in imitation of the ancient Persian academy of Gundeshāpūr, became the main translation center of philosophical and scientific works from the Greek originals which, according to the chronicle, a delegation sent by the caliph had brought from the country of Rūm. However, the *Bayt al-Ḥikmah,* with the name of *Khiẓanat al-Ḥikmah*, already existed under the caliphate of Ḥārūn al-Rashīd (r. 786–809) and the Barmecides, who had started the process of translation from Greek. Al-Maʾmūn may only have given a new impetus to this movement which impacted on the development of Islamic thought and culture. The institution was also linked to astronomical observatories, including one in Baghdad: positioned on the top of the door al-Shammāsiyya and led by the Israelite Sind Ibn ʿAlī, and the second in Damascus, on Jabāl al-Qāsiyūn, the mountain behind the Syrian main town. Both perfected the research of the Persian Nawbakht al-Fārisī; his son, Abū Sahl, Ibrāhīm al- Fazārī, the manufacturer of the first astrolabe; and of Aḥmad ibn Muḥammad al-Farghānī, whose astronomical tables would be used by Christopher Columbus for his research on the route to India. The House of Wisdom also contained, in addition to the observatory, a hospital and a library, and housed research programs in rhetoric and logic, metaphysics and theology, algebra, pharmacology, geometry, trigonometry, physics, and biology. Moreover, these subjects and other academic research were not pursued by specialists operating in separate compartments of knowledge. Many of the men excelling in theology also contributed to the translation of texts on mathematics, medicine, and others. Over the next four centuries in Baghdad, but also in the entire Muslim world, building on the tradition of al-Maʾmūn and his forebears, new institutions arose to supplement the House of Wisdom, and sometimes to replace it. The first major urban hospital came into being in the tenth century while the *madāris Niẓāmīyah* in the eleventh century and *Mustanṣirīyah* in the thirteenth appeared as global universities, even though they were increasingly focused on Islamic studies. In the same century, Baghdad had thirty-six public libraries and more than one hundred booksellers.

The classical studies translation movement survived, after the more traditionalist reaction of al-Mutawakkil, until the tenth and eleventh centuries under the Būyid emirate (945–1055), promoting, however, a decentralization of cultural patronage in connection with the evident devolution of political power. The foundation, in Cairo, by the Fāṭimid caliph al-Ḥākim, in 1005 of the *dār al-Ḥikmah*, probably the most plentiful library of Islamic world, enriched by the favorable climate for the development of ancient studies due to the specific appreciation of the Shīʿī doctrines, permitted the survival of a methodology of rational analysis that sought to reconcile the logic of philosophy and theology with the moral set of rules within Islamic law.

Mathematics and Astronomy: Innovations and New Procedures. The immense quantity of ancient texts available in Arabic stimulated empirical research in the main fields of science, applying discoveries to the needs of everyday life and to technical improvements.

The Persian mathematician and astronomer al-Khwārizmī, for example, following the translation of Euclid's *Elements* and Archimedes's works *The Sphere and the Cylinder, The Equilibrium of the Planes*, and *the Measurement of the Circle,* was able to give relevant contributions, in the ninth century, to mathematics, astronomy and geography. In *al-Kitāb al-mukhtaṣar fī ḥisāb al-jabr waʾl-muqābala* (The Compendious Book on Calculation by Completion and Balancing), a text on mathematics, written in approximately 830 with the encouragement and support of the caliph al-Maʾmūn, there appeared, for the first time, terms such as algebra and the author's methodology for solving linear and quadratic equations through two operations: *al-jabr* (restoring or completion) and *al-muqābala* (balancing). The first is a process of removing negative units, roots, and squares from the equation by adding the same unity to each side; the second is the manner of bringing quantities of the same type to the same side of the equation.

The second major work of al-Khwārizmī, lost in Arabic but extant in Latin, was probably entitled *Kitāb al-Jamʿwa-l-tafrīq bi-ḥisāb al-Hind* (The Book of Addition and Subtraction) according to the Indian calculations, and elaborated, for the first time, the concept of algorithms and the relative calculation using Indian-Arabic numerals developed by the author, including the concept number zero.

The main contribution by al-Khwārizmī to astronomy and geography is related to the 116 tables of Sind and Hind region, with calendrical, astronomical, and astrological data, and the famous *Kitāb ṣūrat al-Arḍ* (The Book of the Image of the Earth), in which he corrects Ptolemy's mistakes, for example, that related to the length of the Mediterranean Sea and the calculation of the Prime Meridian of the Old World.

In continuity with al-Khwārizmī, it is important to mention the Khorāsānian philosopher, mathematician, poet, and astronomer ʿUmar Khayyām, born in Nīshāpūr in 1048. In mathematics and through his influential *Treatise on the Demonstration of Problems of Algebra*, he derived the general method for solving cubic equations and writing on the triangular array of binomial coefficients, known also as Pascal's triangle. While reflecting on the history of non-Euclidean geometry, Khayyām postulated and proved the Euclid parallel-postulate and the Saccheri Quadrilateral. Only six hundred years later, an Italian mathematician, Giordano Vitale, made an advance on Khayyām's book: *Explanations of the Difficulties in the Postulates of Euclid*. In 1079, without the use of a computer, Khayyām calculated the length of a year at 365.242198 days, with an accuracy that only in the twenty-first century, with the use of atomic clocks, could be made more precise: 365.242190 days. It is plausible that this Persian scientist demonstrated that the Earth rotates on its axis by showing a model of the stars to his contemporary, the religious authority al-Ghazālī, in the form of a planetarium. However, Khayyām's relevance is also attributed to his poetic adjustment ability, showed through the *Rubāiyāt* in which clearly emerged his religious-philosophical attitude, in support of the belief that God does not intervene in the physical world.

If in mathematics, Islamic inventions have been partly summarized in the study of al-Khwārizmī and ʿUmar Khayyām, in astronomy, the preferred names are those of Nawbakht al-Fārisī and Ibrāhīm al-Fazārī, to whom are attributed the terms "zenith" and "azimuth," which came from Arabic, and also several names for the stars that referred to the old desert language of poetry: Vega, Altair, Betelgeuse, Rigel, Aldebaran, Feraz, Mirac, Antares, and so forth. In Baghdad as in Damascus, but also in Wāsiṭ (Iraq) and Apamea (Syria), the ʿAbbāsid astronomers calculated that the diameter of the Earth was about 7,909 miles (actually 7,926 miles), while the distance around the Equator was about 24,845 miles (actually 24,906 miles). The Egyptian astronomer and physician Ibn Riḍwān, born in 988, provided the first detailed description of the supernova now known as SN1006, the brightest stellar event in recorded history, which he observed in the year 1006. It was calculated that this supernova was positioned 7,000 light years from Earth and that its interior plasmas burned at 1 million degrees Celsius in the twenty-first century.

Abū Rayḥān al-Bīrūnī in the tenth century discovered how lunar eclipses occur and the different phases of the Earth's moon, attacking the principle of the immutability of celestial spheres and declaring Aristotle's weakness in astronomical theories.

The list of contributors to scientific knowledge is, of course, much longer and more complex; however, it is important to mention also the protagonists that Michael Hamilton Morgan, in *Lost History: The Enduring Legacy of Muslim Scientists, Thinkers and Artists*, defines as "inventors" and "scientists" and as those who broke away from purist academic studies.

Muslim Inventors, Geographers, and Technological Development. It is hard to compare the astronomical and medical innovations that deeply influenced scientific works of the modern age with the devices that have, on one side, played a major role in daily life, and on the other, cannot be compared with discoveries such as the moon's phases, quadratic equations, or the Earth's rotation on its own axis. However, the history of the Islamic world is rooted not only in academia, but also in the welfare system and life's pleasures. The city of Córdoba, in the ninth century, was the largest and most technologically advanced city of Europe; the capital of Andalusia was at the height of fashion, new music, and urban sophistication spurred by an Iraqi musician and arbiter of taste known as Ziryab (Abū l-Ḥasan ʿAlī ibn Nāfiʿ). This talented gentleman, who transformed himself from an Iraqi slave musician into a wealthy Andalusian man, became the expert on how to live in a sophisticated manner. As musician, singer, chemist, cosmetologist, and botanist, Córdobans and Andalusians imitated Ziryab's clothes, haircut, and his manner of speech; he invented the first beauty parlor, which introduced perfumes and cosmetics of his own invention. The first toothpaste in history was pioneered by him, as was the use of crystal in place of metal goblets. Finally, Ziryab improved the technique of playing the *ʿūd*, with the addition of a fifth string, in anticipation of the Spanish guitar.

ʿAbbās ibn Firnās lived in Andalusia a generation after Ziryab and had originally come to the court to teach music under the supervision of the Iraqi's master, but in his middle age he branched out into other areas of specialization. He first invented various glass planispheres and corrective lenses, but also developed a process for cutting rock crystal that allowed Spain to cease exporting quartz to Egypt for this reason. However, Ibn Firnās is notorious for his attempt to fly, supposedly in 852. To make this possible, he constructed an odd suit of silk with wooden reinforcement rods. There are few primary sources on this subject, the first recorded evidence from Maroccan al-Maqqarīʿs dates from seven centuries later. Nevertheless, it seems that after a limited time in the sky, Ibn Firnās was mildly injured and stunned, but not crippled, and, above all, not dead.

The Persian Abū Mūsā Jābir ibn Ḥayyān, born in Ṭūs in 722 is known as one of the first chemists and alchemists in history. He is credited with writing many treatises and articles in addition to 112 books, partially patronized by the famous Barmecides family, the viziers of the caliph Ḥārūn al-Rashīd. The most studied and famous of his books are the Book of Stones, an alchemic text, and the Book of Balance in which he explains his "Theory of the Balance in Nature." Jābir's mystic-scientific side expressed itself in alchemy. According to some, his ultimate goal was not to be able to turn lead into gold, but to resolve the ultimate goal of *takwīn*, literally, the creation of artificial life in the laboratory. The quest was taken up among Europeans some centuries later: in the Faust legend of the lonely researcher bringing life to his homunculus in medieval Prague, and in the cruder and more popular *Frankenstein* by Mary Shelley. However, Jābir needs to be considered in particular for his chemistry: he discovered hydrochloric acid, one of the strongest acids and a major component of the human digestive tract. He discovered nitric acid and by mixing chemicals created a substance later known as *aqua regia* which, though unstable, can shortly after its mixing dissolve a number of precious metals, such as gold and platinum. The works in Latin under the name of Geber (Jābir) include more relevant chemical processes and inventions: the separation of gold from other metals through the agency of lead and saltpeter (potassium nitrate); the concept of a chemical compound; the mineral cinnabar, for example, as being composed of sulfur and mercury; and the process for the purification of mercury. He finally discovered the existence in nature of citric acid found in lemons; acetic acid from vinegar; tartaric acid from wine-making residues; and the chemicals arsenic, mercury, antimony, sulfur, and bismuth, and what is now basic laboratory equipment such as the alembic and retort.

A popular astronomer, the Persian Abū Rayḥān al-Bīrūnī was also a geographer. Al-Bīrūnī's geographic competence is related to specific discoveries: on one of his journeys, he followed the sacred river Ganges from its glacial source to its outflow into the Bay of Bengal. He noted that the size of the river sediment particles was directly related to the speed of the river's current; upstream the outwash was less fertile, while downstream particulates enriched the river with dark mud, resulting is a more productive delta. Al-Bīrūnī exposed how erosion shaped the land from the broad formation of the Earth to the stones of the mountains and sea. During one trip, he was fascinated by the Indian theory that the tides of the ocean are related to the phases of the moon, without, however, the ability to prove it. Through his discovery of seashells at the tops of mountains, he theorized that the Ganges Valley was once under water or surrounded by the sea, as well as the theory of plate tectonics that would be proved centuries later.

Medicine and the Debate on Islamic Decline in Relation to Modern Sciences. Discussion of Islamic contributions to medicine requires the mention of the philosopher Ibn Sīnā (980–1037) and the physician Ibn Zakarīyā al-Rāzī (865–925). The latter is famous for his precise description of smallpox and measles, the description and use of mercurial ointments, and for the history of pharmacopeia that emerged in *Man lā Yaḥduruhu al-Ṭabīb* in which al-Rāzī wrote a home medical manual addressed to the general public. In thirty-six chapters, the author describes diets and drug components that can be found in an apothecary, a marketplace, well-equipped kitchens, or in military camps. Thus, every intelligent person could follow its instructions and prepare the proper recipes with good results. A few decades after al-Rāzī's death, another physician and philosopher achieved great results in the medical field: Ibn Sīnā. His *Canon of Medicine*, translated many times into Latin, remained until the eighteenth century the most studied text in the medical field. Ibn Sīnā was the first to organize the four causes originated by Aristotle into a logical, scientific framework for medicine. This is now the background of every modern science.

The decline of the Islamic Near and Middle East, as well as the Indian Subcontinent and Chinese early inventive culture began during Western expansion. The historical and geographical devolution of modern and contemporary events has shown that the world centers of the sixteenth and seventeenth centuries were not Mesopotamia, the Nile, and the Indus Valley anymore. Geographic expansion and colonization stimulated technological improvements and scientific progression that created, in a couple of centuries, a gap concerning military technology and industrial production in particular. Europe became industrialized while other parts of the world remained more primitive. Nevertheless, although this scientific and technological gap clearly emerged in the eighteenth century, decency and culture did not belong exclusively to the Western world: underwear, for example, was imported by the British from the Indian subcontinent during the eighteenth century. Moreover, because science and development are based on the support and funding by a nation's leadership, Muslim science declined when its nations, in the seventeenth century, had to shift its resources to military defense.

It is evident that the technological gap, certainly relevant in relation to a military and economic decline, was a result of political choices, rather than decisions made in the cultural and religious spheres. Ignaz Goldziher's theory, which emerged in the famous article "The Attitude of Orthodox Islam toward the Ancient Sciences," asserts that Orthodox Islamic traditionalism attempted to limit and silence scientific methodology and Greek logic in connection with religious predestination and more popular beliefs. Dimitri Gutas rejects this theory in the final chapter of *Greek Thought, Arabic Culture: The Graeco–Arabic Translation Movement in Baghdad and Early ʿAbbāsid Society*. Similarly, George Makdisi in *The Rise of Humanism in Classical Islam and the Christian West* and Wilferd Madelung in *Religious Schools and Sects in Medieval Islam* argue that Muslim *fiqh,* specifically the Islamic Ḥanafī juridical school, encouraged the teaching of logic and scientific methodology at all times, particularly during the peak of Ottoman civilization. Ibn Sīnā's philosophy and translations from Greek and Latin were frequently used by Ottoman historians such as Kātib Celebi and Ḥusayn Hezārfenn in the seventeenth century. Meḥmet II Fātiḥ (1451–1481) held in special regard Alexander the Great and the ʿAbbāsid caliph al-Maʾmūn.

Precise policy choices, such as capitulations, resulted in the lack of encouragement for boosting navigation, the lack of construction of new sailing vessels, and the lack of investment in preliminary processes of industrialization. These factors caused the Middle East and the Islamic world to lose the confrontation with Europe without profiting, and moreover the advantageous geographic position that the Islamic world had in relation to the Asian continent.

[*See also* Translation of Greek and Persian Texts into Arabic.]

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Marco Demichelis

Majrīṭī, al- Abū al-Qāsim Maslamah ibn Aḥmad al-Faraḍī al-Majrīṭī (d. c. 1007 CE) was a tenth-century astronomer and mathematician. He was born in the mid-tenth century in Madrid and died in Córdoba, but little else is known of his life. His work and legacy were largely spread by his many influential students who included Abū al-Qāsim Aṣbagh, or Ibn al-Samḥ (d. 1034–1035 CE), Abū al-Qāsim Aḥmad, or Ibn al-Ṣaffār (d. 1035 CE), and a myriad of other Andalusian scholars. His work would spark the interest of many European scientists, initiating a period of scientific exchange as Arabic treatises were translated to Latin. He became one of the most influential Muslim scientists in Europe.

Biographical details of his life are few. His teachers may have been ʿAbd al-Ghāfir ibn Muhammad al-Faraḍī and ʿAlī ibn Muhammad ibn Abī ʿĪsā al-Ānṣārī. Scholars believe he functioned as the primary astronomer in the court of the caliphs of Córdoba. In AH 979, it was recorded that he made astronomical observations including the star Regulus. From such observations and his extensive understanding of Ptolemy's *Almagest*, he was able to establish elliptical longitude of this and other stars. This has led some to suppose it was during this point in his life he began his emendation of al-Khwārizmī's astronomical tables.

Al-Majrīṭī's acumen remains his legacy, as scholars have attributed about a half-dozen works to his name alongside a handful of highly dubious materials. He founded a school dedicated to the study of commercial arithmetic (*muʿāmalāt*) and astronomy. Most sources attest that he authored one treatise, known by variant names including *Thimār al-ʿadad* and *Muʿāmalāt*, on commercial arithmetic specifically addressing sales and taxation as it pertained to merchants and their business. It is likely he and some of his most prominent students, including Ibn al-Samḥ and probably Sulaymān al-Zahrāwī, authored more in this field. It has been speculated that the source material for these treatises would have been works of early Greek mathematicians, such as Euclid and Archimedes. While these works were not preserved in their entirety, scholars believe