The Islamic Antecedents of the Western Renaissance

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"O Muslims, you ask me what I am?
– Half of me comes from here, half from everywhere.
– Half of me comes from the pearls of the sea, half from distant shores."

Jalal al-Din Rumi (1207-1273)

Since the time of the Renaissance, it has been believed in the West that Greco-Roman Civilization developed solely between Athens, Rome and Paris. In so doing, we forget the detour that Greek culture took into Muslim culture over a period of several centuries, and the influence of this culture on Muslim philosophy and science. This assumption also fails to take note of Muslim influence on Europe, in which Andalusia and Sicily acted as intermediaries. In order accurately to trace the spread of knowledge from Greece we must follow a path leading from Athens to Baghdad and Cordoba before reaching Paris. If we omit this historical reality, we underestimate the role played by Eastern Christians and Jews in the transmission of Greek knowledge to Islam, and from Islam to the West.

After the Emperor Justinian closed the School of Athens in 529 C.E., ancient knowledge migrated toward the future Islamic lands. Particularly in Baghdad, a thirst for knowledge developed, giving rise to an immense labor of translation of Greek, Syriac, and Pahlavi texts, as well as numerous discoveries in many other areas of knowledge. This was the first time in human history that learned men from all over the world and from all social origins met in the great centers of learning, such as Baghdad, Cairo, Maragheh, Isfahan, Marrakech, Cordoba, Seville, and Palermo, to develop a new vision of the world that may very well have served as the inspiration for the Western Renaissance.

The Great Scientific Centers of Late Antiquity

While intellectual life in the West, undermined by waves of invasions, had taken refuge inside monastery walls, two great empires faced off in the East: the Byzantine, inheritor of the traditions of Greece and Rome, and the Persian, which had been ruled by the Sassanid dynasty since 226 C.E. The great centers of pagan culture of Late Antiquity were located in Alexandria, Egypt, Ra's al'-Ain, Syria, and Jundishapur, Iran. Their great influence on the development of Arab science deserves some attention here.

Students came to Alexandria from all over the Near East to study at its renowned school. Among the scholars who taught there were Alexander of Tralles (525-605), a Byzantine doctor whose works Razi often quotes; Paul of Egine, who was profoundly influenced by Galen (the latter's works were rapidly translated into Syriac and then Arabic), and who became one of the key medical authorities in the Muslim world; Jean Philopon, known as Jean the Grammarian, who lived in the first half of the sixth century and wrote commentaries on several of Aristotle's treatises; two important mathematicians: Diophante (who lived in the century before Ptolemy) and Ptolemy, who studied equations. Finally, about a hundred years later, there was Pappus, who worked on angles and curves and edited a treatise on Greek geometry and arithmetic. His work was taken up in the West some thirteen centuries later. Also, the Andalusian doctor, Al-Zahrawi, famed for his surgical treatise, seems to have been heavily influenced by the School of Alexandria.

Sergius, a doctor and Syrian Orthodox priest who studied at the School of Alexandria, worked in Ra's al-'Ain and died at Constantinople in 536. According to the great Arab translator Hunayn Ibn Ishaq, it was Sergius who produced the Syriac versions of twenty-five of Galen's works.

Arab science, which inherited much of the legacy of the School of Alexandria, was also influenced by the school of medicine established by the Sassanids in Jundishapur (a city in southwest Iran) and which remained an important center of learning until the tenth century. Originally, Greek medicine was taught in Syriac and Persian translation by Nestorians who had sought refuge in Jundisha-

pur after their expulsion from Edessa in 489. A second wave of Greek ideas arrived with a group of Neo-Platonic philosophers, who came after their school in Athens was closed by Justinian in 529. While Christianity hounded pagan Greeks and suppressed ancient philosophy, the city of Jundishapur, at its height, under the rule of Khosroes Anouchirvan, became a lively center of learning where Greek, Persian, Syrian, Jewish, Christian, and Indian ideas were exchanged in an admirably tolerant atmosphere. Beginning in the Abbasid period, these various elements had a profound influence on Islamic intellectual life. In Baghdad, during the reign of Harun al-Rachid, the school's director, the Nestorian Jibra'il Ibn Bakhtichu', was entrusted with the task of constructing a hospital modeled on the one in Jundishapur. Later he became official doctor to Caliph al-Mansur. The great astronomer, Thabit Ibn Qurra (d. 901), born in the pagan center of Harran and who lived at the court of the Caliphs of Baghdad, translated a number of mathematical treatises from Greek.

The Arab Conquest

After the conquest, the Arabs respected the heritage of Late Antiquity. A century after the death of the Muhammed, the Muslim empire stretched from Spain to Turkestan. The Umayyad dynasty (661-750 C.E.) moved the capital of the empire to Damascus, Syria. It was in this period that the Arabic administration was put into place and the legitimacy of the Caliphate recognized. At the same time, the oldest public libraries in the Arabo-Muslim world were founded: among them was one, created by Mu'awiya, that contained collections of hadiths and other works edited at Mu'awiya's behest. This library was inherited by his son, Khalid Ibn Yazid, who devoted his life to the study of Greek science and who commisioned the translation of works on alchemy and medicine.

Under the Abbasid dynasty (750-1258), Islam reached India and Arabic became the administrative language of this powerful empire. The new imperial capital, Baghdad, symbolized its greatness. Baghdad was later surpassed, for a period of some fifty years, by a second cultural and artistic center, Samarra, located on the banks of the

Tigres river. The thinkers, writers, and scholars who gathered there, inspired by Antiquity, attempted to construct what Danièlle Jacquart and Françoise Micheau have called "a new cultural space" in the Arabic language. Why did this Abbasside "Renaissance" occur?

As A. Hasan and D.R. Hill see it, the fundamental cause was Islam. Sharing a single religion, worldview, and an identical literary and scientific language, the Islamic countries were assured cultural unity. By this means, the Greek element was mixed with the Hebrew, Turkish, Chinese, Persian, and Indian. The great novelty of Muslim civilization was its ability, in all domains, to achieve symbiosis and in its spirit of tolerance. Thus, although burning with an unshakeable faith, Muslims respected the rights of the "People of the Book," permitting old temples to be repaired, although forbidding the erection of any new ones within the boundaries of "Dar al-Islam". Moreover, based on the teachings of the Koran, Muslim civilization took no notice of social class, meaning that a slave could potentially rise to occupy an important post. In the domain of philosophy, Ghazali in Baghdad refuted Aristotle's ideas: Averroes in Andalusia provided a retort. It was this spirit of tolerance – which was largely absent in the Christian Medieval World – that allowed the free exchange of ideas to extend from China to Spain. As long as this openness of spirit continued, Islamic civilization flourished. However, when dogmatism finally carried the day, it brought with it an ineluctable decline.

Meanwhile, Islamic civilization gave rise to a veritable politics of culture. This civilization, which could only flourish under the authority of a stable government, adopted an enlightened attitude in matters of science. Even when the Empire began to fragment, each individual State, for reasons of prestige, encouraged the process of arabisation: translation, the foundation of scientific academies, schools, laboratories, libraries, and observatories, patronage of artists and scholars, basic and technological scientific research, as well as the initiation of certain projects and State industries, all continued.

Through arabisation the Arabic language became the tongue of all Muslim peoples, from Baghdad to Cordoba. Beginning in the Umayyad period, the Caliphs regarded this fact as an essential component of their scientific policies.

Next came the role of education. The type of university (*Nizamiyya*) that the Seljuk Vizier Nizam al-Mulk founded in Baghdad became a model throughout the Empire. The number of schools (*madrasas*) that existed at the height of Muslim influence is simply astounding (such as Mustansiriyya, Halawiyya, Jawziyya, or al-Azhar). Large madrasas existed in all cities; and Wassaf, in his "History," mentions twenty of them in Damascus and thirty in Baghdad alone. Some of them had the structure of a hospital-mosque, providing stipends for deserving students. However, the idea that the madrasa is the inspiration for the European universiy – of which the oldest ones, in Palermo, Bologna, Montpellier, Paris, and Oxford, date back to the twelfth and thirteenth centuries – must be approached with caution.

It should also be mentioned that Chinese paper, which reached Islam around the year 725, made books less fragile and costly than a roll of papyrus or parchment. It was at this time that encyclopedias were first produced, in order to gather within a single volume information hitherto dispersed. Equally, the availability of paper, along with Baghdad's over one hundred libraries, assured the copying of manuscripts. These new books enjoyed wide circulation and were stored in libraries.

Baghdad in the Ninth and Tenth Centuries: At the Crossroads of Civilizations

Two centuries after the closing of the School of Athens, Baghdad, the city of salvation, "Madinat-al-salam," which had been founded in 762 by the Caliph al-Mansur, rapidly became a cultural crossroads and the true intellectual capital of the East. According to André Miquel, this "immense and tentacular" city, with nearly a million and a half inhabitants, was a place where people of all origins came together. It was also a rallying point of ancient cultures, such as the Indian, Greek, and Iranian. It was here, in this intellectual whirlwind, that the "Bayt-al-Hikma," or "the House of Wisdom" arose. Where did it come from?

It was Harun al-Rachid (766-809) who founded, in Baghdad, the important library known as "Khizanat al-Hikma" (the library

of wisdom). Early on it employed such translators as Salm al-Harrani, who appears to have translated Aristotle's *Categories*, *Hermeneutics*, and *Analytics*, as well as Porphyry's *Eisagoge*. By obtaining philosophical and scientific treatises from Byzantium and Cyprus, the Caliphs made it possible for a group of scholars, representing a variety of backgrounds and beliefs, to translate into a single language texts that had hitherto existed separately in Greek, Syriac, Pahlavi, or Sanskrit redactions.

The Caliph Harun al-Rachid also entrusted Jibra'il Ibn Bakhtishu', a Christian physician from the school at Jundishapur, with the task of setting up a hospital in Baghdad. True to the eclectic tradition associated with Jundishapur, the Indian Mankha translated the *Susrata-samhita*, a work of Sanskrit medicine, while Razi used the hospital as a site for a series of conferences. D. M. Dunlop, G. S. Colin, and B. N. Sehsuvaroglu have pointed out that these hospitals, which are called "bimaristan" in Persian, offered both a theoretical and practical medical education. Doctors examined patients, recorded their observations in a notebook, and wrote prescriptions. Each hospital had a pharmacy that distributed medicines under the supervision of a pharmacist-in-chief. There were even field hospitals whose purpose was to treat victims of battle wounds.

However, it was during the reign of al-Ma'mun (813-833) that the library of Baghdad, the "Bayt al-Hikma" or "the House of Wisdom", reached its most fertile period. Al-Ma'mun, the seventh sovereign of the Abbasid dynasty and eldest son of Harun al-Rachid, was an enlightened monarch. Like any prince, he had received, from an early age, a classical education, studying song, poetry, literature and the religious sciences. His Caliphate marked a golden age in the history of the dynasty. He restored the Empire's unity, which had been threatened by a long civil war following the death of his father. It was also during his reign that the doctrine of *mu'tazilite* was developed, proclaiming reason as the criterion of truth. The consequences of this principle were enormous, as much in the political as in the scientific realm. Opposing traditionalists who relied solely on the authority of the Koran and Sunna, Al-Ma'mun did not hesitate to make use of Greek philosophy in order to explain God's oneness. We can thus legitimately speak of the ninth century as having seen a great cultural turning point.

Ibn al-Nadim, to whom we will return below, describes a dream that the Caliph al-Ma'mun had one day sometime toward the beginning of the ninth century: "There appeared before him a man, seated on a couch. He had a friendly expression, a fair and ruddy complexion, a broad forehead, blue eyes, and his eyebrows were joined. Taken aback by the sight, the Commander of the Faithful asked him: 'Who are you?' The man answered: 'Aristotle.' Spellbound by the answer, and permitted to ask other questions, the Caliph asked: 'What is the good?' 'That which is good in the mind,' Aristotle answered. 'And what comes next?' 'That which is good in the law.' 'And then?' 'That which the people respect.' Finally, Aristotle advised al-Ma'mun to welcome to his court anyone who could instruct him in matters of alchemy (alchemy, that is to say the science that is not in the Koran) and to adhere strictly to the doctrine of Tawhid, or the oneness of God."

Ibn Nadim adds that, as a result of this dream, Al-Ma'mun sent scholars off in search of books of ancient philosophy and had them translated for him. It was in this way that translations from Greek into Arabic truly became a matter of State.

According to A. I. Sabra, the great translators, who were often experts in their field, came from a wide variety of ethnic and religious backgrounds. For example, the Persian astrologer Ibn-Nawbakht translated for Harun-al-Rachid from Pahlavi into Arabic. Al-Mansur had Al Fazari (of Arab blood) collaborate with a Sindhi Indian in a translation of a Sanskrit work: the "Astronomical Sindhind." The greatest translator of Greek and Syriac medical treatises, Hunayn Ibn Ishaq (b. 873), was a Nestorian Christian who spoke both Syriac and Arabic. Having studied medicine in Baghdad and then, either in Alexandria or Byzantium, the Greek language, Hunayn returned to the Abbasid capital where he was renowned as a translator, professor and court doctor to the Caliphs. D. Jacquart and F. Micheau describe him as extremely serious and thorough: comparing several manuscripts in order to arrive at a faithful original text, Hunayn would then translate it, as a first step, into Syriac. Perhaps in connection with the "Bayt al-Hikma," he headed up a team of scholars who translated the texts of Hippocrates and Galen into Arabic. He was also a remarkable physician, and his work as both generalist and special-

ist – in ophthalmology, nutrition, dental therapy, and pharmacopoeia – was considered authoritative. His *Kitab al-Masa'il fi al-Tibb* was one of the major sources of Medieval medicine, both in the East and West. He also devoted himself to the study of astronomy and philosophy.

Hunayn played a decisive role (Ibn Nadim mentions some 174 titles) in the translation of Greek, Persian, and Indian science into Arabic. His son, Ishaq Ibn Hunayn, who knew Greek, translated into Arabic philosophical works of Aristotle, *The Elements* of Euclid, and Ptolemy's *Almagest*.

Apart from translation activity, the "Bayt al-Hikma" was also a place for meetings, discussions and philosophical discourse. Mas'udi, in a work entitled *Muruj al-Dhahab*, refers to a practice that is without precedent at this period of history: during the Tuesday meetings that he organized, Mas'udi endeavored to generate discussion of political and religious differences not only between representatives of different religions (Jews, Christians Muslims, Zoroastrians, and Manicheans), but also between supporters and critics of the *mu'tazilite* doctrine. Scholars, researchers, and theologians would meet in a hall where they would share a meal, wash their hands, and then engage in discussion in the presence of the Caliph. These discussions would last until evening, and the participants would return home after dinner. Al-Ma'mun considered this kind of debate an excellent way of engaging in the search for truth. In his "History of Nawbakhti," Abbas Iqbal reports these words of the Caliph: "An enemy can be dominated only with reason and not by force, because the former is eternal, while the latter collapses as soon as the force is removed." Although the example of al-Ma'mun was not imitated by his successors, the memory of these "Munazirat" (debates) was engraved in the memory of the men of science and in books, giving rise to a literary tradition that has endured to our day. The Institution employed a director, copyists, bookbinders, and interpreters of tradition. The library was open to the public at large, not only to the entourage of the Caliph. It was frequented by scholars (Khwarizmi was among their number), astronomers, and mathematicians. Historians have accorded "Bayt al Hikma" the rank of fourth cultural center of humanity, after Plato's Academy, Aris-

totle's Lycée, and the School of Alexandria. It was from Baghdad that the works translated into Latin were sent to Andalusia (the cultural center of which Maimonides was to become the symbol).

Abu Yusuf al-Kindi (born in 801), who was also in the employ of the Caliph, was one of the most learned men of this era. Called "the first Arab philosopher," and of a universal spirit, he studied the propagation of light as an optical phenomenon, and did work in geography, geology, meteorology, astronomy, and astrology. He also carried out research on clocks and astronomical instruments and was interested in sword making. He wrote works on medical remedies and described their composition. But it was in the area of philosophy, as Colin Ronan has pointed out, that the true genius of al-Kindi shined. His teachings were highly influential during the Middle Ages. Himself influenced by Aristotle, Plato and Plotinus, he created a synthesis of Islamic and pagan knowledge, the latter having undergone a revival at this time in "the House of Wisdom" at Baghdad. As the tutor of the future Caliph al-Mu'tasim, al-Kindi's influence at court was enormous.

The sovereign also sponsored the first systematic series of astronomical observations in the Islamic world, beginning in Baghdad in the al-Chammasiyya quarter, then continuing in Damascus in a monastery on Mount Qasyun. However, the structures that were to be used in the systematic observation of the sun and moon, of the stars and perhaps even the planets, were never fixed in place because they were only used for a very short period of time. What was the reason for this infatuation with mathematics and astronomy? It was because the stars were used to guide ships, and the observation of the stars was thus indissociable from the opening of new commercial maritime routes. The stakes were therefore large.

The mathematician Muhammed Ibn Musa Khwarizmi was one of the key figures of the reign of al-Ma'mun. He developed a series of "Zij," or astronomical tables, called "Zij al-Sindhind," because they were based on Indian tables obtained in Baghdad. This is the oldest astronomical work of Islam that has been preserved in its entirety. Khwarizmi also wrote about the Greek astrolabe, an instrument that Islam was to make extensive use of. He was also, without question, the greatest mathematician of the

ninth century. His work on equations of the first and second order, entitled *Al-Jabr wa al-muqabala*, was a veritable "sum" and was "absolutely without precedent in any language whatsoever" (S. H. Nasr, 1979). As early as 830 he systematically described Indian numbers and the rules of Indian calculation, and it was thanks to this work, translated into Latin under the title *Algoritmi de numero Indorum*, that the Indian system reached the West. We owe the word "algorithm" to Khwarizmi.

'Ali ibn Sahl al-Tabari, who was a contemporary of Hunayn Ibn Ishaq and thus lived during the blossoming of Arab medical science, was born in Marw, Iran, to a family of Syrian Christian scholars sometime between the years 780 and 810. He served at the court of Baghdad during the reigns of several Caliphs and converted to Islam. His *Firdaws al-Hikma*, which was completed in 850, was influenced by Greek, Persian, and Indian medicine, whose traditions are in some sense complimentary and in others antagonistic. It is also true that, at the instigation of the Caliph Harun al-Rachid and his Barmekid Viziers, ancient Sanskrit treatises were translated into Arabic; and also, doctors of Indian origin were known to have practiced at Baghdad at this time.

In the field of astronomy, we find the same two currents. The first of these was based on the *Sindhind*, translated in the 770s and based on an Indian model. This text made possible the spread of a more efficient trigonometry than the one the Greeks made use of. However, once the *Almagest* was translated into Arabic, Ptolemy's system triumphed. It exercised an important influence on Muhammed ibn Jabir al-Battani (858-929), one of the most famous Muslim astronomers, whose reputation rests on a book of astronomical tables, the *Kitab al-Zidj* (this book is something of a symbol of the victory, for Muslim astronomy, of the Ptolemeic over the Indo-Persian tradition). In Western Europe, from the fifteenth to seventeenth centuries, some of the giants of astronomy, such as Copernicus, Kepler, Tycho Brahé and Galileo, made use of it. A. I. Sabra, in an essay included in Bernard Lewis's anthology "The Islamic World," wrote: "Although Greek learning had played a predominant role, historians have rightly emphasized the novelty of the kind of research that was undertaken at Baghdad. For the first time in history, science really became international on a large scale."

The Multiplication of Centers of Knowledge: A History of Rivalries

The development of "Bayt al-Hikma" was part of a much broader historical-cultural context that touched the entire Muslim world. Beginning in the ancient Abbasid period, some provincial governors of the Empire, who were theoretically under the control of the Caliph, broke free and founded the first independent Turkish dynasties (for example, the Tulunids in Egypt, 868-905). In the East, the Turkish Ghaznavids arose, dominating Persia, modern day Afghanistan, the provinces of India, Punjab and a part of Gujarat. Their capital was originally Ghazna and later Lahore. Many of these sovereigns, notably in the Persian provinces, supported the sciences and the arts and letters in order to increase their political prestige. Beginning in the eleventh century, hospitals, madrasas, mosques, libraries, Koranic schools, and Sufi convents, were converted to *waqfs*. A system of gift-giving, the proceeds of which were devoted to charitable and philanthropic endeavors, guaranteed their financial autonomy and smooth functioning.

What then happened to Baghdad's Bayt al-Hikma? According to W. Heffening and J. D. Pearson, after the transfer of the Caliphate to the "round city" of Samarra under the reign of al-Mu'tasim (successor to al-Ma'mun), the Bayt al-Hikma lost its academic character. It instead became known as "Khizanat al-Ma'mun." Visited by scholars until the end of the tenth century, it then ceased to be mentioned in any documents. It is believed to have been incorporated into the library of one of the Caliphs or broken up by the Seljuks.

The Bayt al-Hikma period was followed by another, the "Dar al-'ilm," which was a semi-official institution that took the form of a public library whose aim was to spread doctrine and teach the natural sciences. The most important "Dar al-'ilm" or "House of Knowledge" was the one founded in Baghdad, between 991 and 993, by the minister Ibn Ardashir. It contained more than ten thousand volumes touching on various sciences, some of which were considered masterpieces of calligraphy. It was visited by many men of letters, including the poet Abu 'Ala al-Ma'arri in 1009-1010. This library, which also received works donated by contem-

porary authors, was set afire at the time of the arrival of the Seljuks, in 1055 or 56.

It was during this period (either in 987 or 988) that Ibn al-Nadim, the son of an important bookseller in Baghdad, drew up a catalogue encompassing all the works then existing in the Arabic language: this *Fihrist* was a veritable encyclopedia of Medieval Muslim culture. Among the 430 medical titles mentioned, 174 were not originally written in Arabic but rather in Greek, Sanskrit, Pahlavi, or Syriac. They were translated into Arabic during the course of the eighth and ninth centuries. Three names predominate: Hippocrates, Rufus of Ephesus, and especially Galen, who alone is represented by 125 titles. Among the 256 original Arabic titles, there are works by Hunayn ibn Ishaq, Qusta ibn Luqa and Yuhanna ibn Masawayh, three Nestorian Christians who lived in the first half of the ninth century, and 144 medical treatises by Razi.

Among the Arab travelers of the tenth century the most outstanding was Abu al-Hasan Mas'udi, famed for his work of history, *Muruj al-Dhahab*. Leaving Baghdad in 915, he spent the rest of his life criss-crossing the Islamic world, India, and East Africa. He died in Cairo around 956. Mas'udi, a geographer and historian who stressed direct observation, was certainly one of the most original Islamic thinkers and, perhaps, one of the least understood.

In Egypt and Syria, the Turkish dynasties of the Tulunids (868-907) and Ikhchidids (935-969) were followed by dynasties of different ethnic origin. The Berber dynasty of the Fatimites (969-1171), whose power extended to Sicily, took up residence in Cairo, which later became the capital of Egypt. Their successors, the Ayyubids (1169-1250), of Kurdish extraction, were to be the most bitter adversaries of the Crusaders. The Sultan Saladin (Salah al-Din), under whom Jerusalem was recaptured in 1187 (and whose opponent was Frederick Barbarossa), became one of the greatest figures of Islam.

In Fatimite Egypt (969-1171), the Caliph al-Hakim had a "Dar al-Hikma" constructed at the extreme northwest corner of his palace in Cairo (the city had approximately 500,000 residents at the time). According to D. Sourdel, it included a library, reading room, and space for classrooms. This institution outclassed all others of the same type. Entry was free and open to the public. Y.

Eche has written that service was guaranteed by salaried librarians and that scholars received allowances so that they could carry out their research. Ink, quills, and paper were provided free of charge. The Caliph called on jurists, doctors, interpreters of tradition, grammarians, astronomers and logicians to teach the various scientific disciplines. Meetings of learned men were also organized. In 1043, the catalogue mentions some 6,500 works of astronomy, architecture, and philosophy. Among its treasures, it possessed a brass globe that tradition claimed was constructed by Ptolemy and which had an inscription attesting to the fact that it had been bought by Khalid Ibn Yazid ben Mu'awiyaa. The library remained intact until the death of the final Fatimite Caliph, al-'Adid. Associated with Ismaelian doctrine, the library was looted in 1068 and later saw its various collections dispersed by Saladin.

Ibn al-Haytham, who was born in 965 in Bassora, Iraq, was the greatest Islamic physicist. He first came to Egypt during the reign of the Fatimite Caliph al-Hakim. Having failed in his project to irrigate the waters of the Nile, he feigned madness in order to avoid the Caliph's wrath and remained under house arrest until his master's death. Ibn al-Haytham was the first man to attack Ptolemy's planetary theory, thereby preparing the way for the work of al-Tusi and his collaborators at Maragheh. Al-Haytham was also a great optician who set himself apart from Greek science by stressing scientific experimentation in a totally new way. His work was often quoted by learned men in the Medieval West and his theory on the refraction of light was used in the seventeenth century by Kepler and Descartes.

Abu al-Hasan Ibn Yunus, one of the great Muslim astronomers of the Middle Ages, lived toward the end of the tenth century at the Fatimite court in Cairo. According to J. Samso, he probably carried out his experiments with nothing more than a private observatory and the few portable instruments he had at his disposal. However, this did not prevent him, in 1007, from producing astronomical tables that were among the most accurate of their time. He also produced a major work devoted to the astronomical calculation of the hours of prayer. In the area of mathematics, he worked on orthogonal projections and studied, for the first time, the oscillations of a pendulum, which made clock building possible.

According to W. Heffening, libraries existed in Persia as early as the Achmenid period but were destroyed by Alexander the Great. Under the Abbasids, libraries could be found at Ram Hurmuz (founded by Ibn Sawwar), Rayy, and Isfahan (this last was looted by Ghaznavid troops in 1029: it was transferred to Ghazna and was later destroyed by the Sultan Ghuride Ala al-Din Husayn). Other libraries, scattered here and there, made possible the acquisition not only of traditional knowledge but also an acquaintance with the sciences of the Ancients. At Shiraz, the famous library founded by 'Adud al-Dawla (959-82) contained one copy of every available book in every branch of knowledge. These volumes, acquired either through purchase or copied by scribes who worked for the library, were arranged on shelves according to subject. Certain works, of which the library possessed several copies, could be borrowed. The Koran was usually allotted a separate space. Most libraries had a director (*sahib*), several of whom were famous scholars, one or more librarians (*khazin*), scribes (*nasikh*), and attendants (*farrash*). These institutions were open to all free of charge, and paper, ink, and reed quills were provided by the administration. Some private libraries even offered room and board to scholars who had traveled from distant regions. As Heffening writes: "It can be stated without fear of error that the Muslim libraries, which were free at this period of time, were in every way several centuries ahead of Western libraries. When, in the thirteenth century, the Mongols invaded Persia, a vast number of priceless books was destroyed. Although some of the Sultans of Delhi acted as patrons for scholars and were faithful friends of knowledge, there is no evidence to suggest the existence of any libraries there at this period of time. The oldest known library in this region dates from the time of Saint Nizam al-Din Awilya, a contemporary of the Sultans Khaldis and Tughlukides."

The Buwayids: from Shiraz to Baghdad, the Tenth Century

Opened in 982, Baghdad's most famous hospital was founded by the Buwayid Emir 'Adud al-Dawla (949-983) and enjoyed an

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excellent reputation: there were approximately 24 doctors, some of them specialists in fields such as ophthalmology, surgery, and orthopedics, associated with it. Several of their number provided both medical services and instruction. Heavily endowed, it was still operating at the close of the twelfth century. During conferences held at the hospital, works produced by the school of Jundishapur were read. It is believed that Ali ibn al-Abbas al-Mjusi, known as Haly Abbas in the West, worked at this establishment. His "Royal Book" (*al-Kitab al-Malaki*), which was perhaps the best synthesis of scientific medical knowledge then available, recommended that apprentice doctors supplement their education by frequent visits to observe hospital life.

Farabi, whom the Latin texts of the Middle Ages call Alfarabius, was one of the most famous Muslim philosophers. He was nicknamed "the second master," the first being Aristotle, which bears witness to the esteem with which Muslims held Alexander's tutor. He made his career in Aleppo, as a member of the sovereign Hamdanid Sayf al-Dawla's entourage. In the areas of logic, the natural sciences, psychology, and metaphysics, Farabi was very much under Aristotle's influence. He believed that Greek philosophy could provide the Caliphate with a foundation for the kinds of reforms it sorely needed. He dreamed of the perfect city, nation, and State. In matters of political science, he was largely in accord with Plato's *Laws* and *The Republic*. Indeed Farabi attempted to harmonize the systems of the two Greek philosophers, draping Aristotle's logic in Plato's mysticism, although this in fact was but a philosophical ruse intended to trick the theological fanatics who opposed him. Farabi had a significant influence on Eastern philosophers such as Ibn Sina, Ibn Rushd, and Maimonides.

The director of the Baghdad hospital (Iraq was at this time dominated by the Chi'ite Buwayids, who promoted intellectual and scientific life) was the most famous of all Islamic physicians, Abu Bakr Muhammad ibn Zakariyya' Razi, the "Arab Galen" who was known to the West as Rhazes. He was born around the year 865 in Rayy, a Persian town a few kilometers from Teheran. Originally a lute player, Razi took up alchemy before turning to medicine at an advanced age. Although his philosophical works are lost, his *Treatise on Small Pox and Measles*, which was translated in Europe

throughout the eighteenth and nineteenth centuries, was consulted by Western doctors into the modern period. Razi's *oeuvre* is vast: 184 titles, ranging over subjects as various as medicine, logic, philosophy, theology, the natural sciences, alchemy, astronomy, mathematics, and others. Rejecting blind obedience to the Ancients, Razi stressed daily observation, minute description, and precise diagnosis. He presented himself as an opponent of Galen.

The entire career of Avicenna (Ibn Sina, 980-1037) took place in the great Iranian courts of the tenth and eleventh centuries. Famed as both a doctor and philosopher, he belonged to a family of senior officials in service to the great dynasty of the Samanids (Emirs of Iranian origin, in power from 875 and whose capital, Bukhara, was an important center of the Persian renaissance). Although he was without formal training in either the natural sciences or medicine, renowned doctors were working under his direction when he was only sixteen years old. By the age of eighteen he had mastered all the sciences of his time. Then, with the advance of the Ghaznavids, whose territorial expansion cut directly into the territories dominated by the Samanids, Ibn Sina was forced to flee. Life's tribulations led him from Bukhara to the cities of central Iran (Gurgan, on the banks of the Caspian Sea, then to Rayy, and finally to Hamadan and Isfahan), where petty lords held sway in Buwayid fiefdoms faithful to Iranian traditions. Sometimes imprisoned, sometimes valued for his political counsel and medical knowledge, he even became the Vizier to a Buwayid Emir. A. M. Goinchon describes him thus: Ibn Sina was not a scholar shut up inside books but a man who lived in the real world: during the day he worked on affairs of State and provided medical services; at night, often in flight, he wrote his works on horseback, on bivouac with troops, or even in prison. There is a large body of Iba Sina's work that has come down to us. Known mostly as a physician and philosopher, he also wrote on the natural sciences, physics, astronomy, mathematics, music, morality and religion. In his role as a statesman, he even touched on economic and political matters. As a poet, he put his works of logic and medicine into verse, which facilitated memorization.

His *Canon of Medicine* presented the totality of medical knowledge of the time, enriched by his personal observations. Having

been translated into Latin, this work was taught in Western universities for centuries. Equally, his handbook of medical theory and practice, the *Urjuza fi al-Tibb*, was translated several times between the thirteenth and seventeenth centuries under the title *Cantica Avicennae*. As for the philosophical works of Avicenna, they have come down to us in mutilated form. Influenced by three great masters – Aristotle, Farabi, and Plotinus – he considered metaphysics and logic as the summit of the science of being. He himself was influential on both Western and Eastern philosophy, as can be seen in the works of Albert the Great, Thomas Aquinas, Duns Scottus and Roger Bacon.

Biruni (973-1048), one of the great minds of the Medieval Islamic world, lived under the Ghaznavids toward the end of the tenth century. Originally from Khwarezm, which is located at the edge of Central Asia, he was a contemporary and compatriot of Ibn Sina. However, unlike Avicenna, who became a dominant intellectual figure in the West, Biruni was totally ignored, in spite of the fact – as D. Jacquart and F. Micheau have pointed out – that Biruni's adventurous spirit of critical inquiry was similar to the modern scientific ideal.

Around the year 1000 Biruni completed his first major work devoted to the study of the chronology of the ancient nations. In 1017, the powerful Ghaznavid Sultan, Mahmud, conquered Khwarezm, taking numerous prisoners with him. Biruni, who was one of them, took up residence at the court of Ghazna. Taking advantage of the Sultan's military expeditions to the Indus valley, Biruni learned Sanskrit, familiarized himself with Indian sciences, and increased his observations and reflections. In his famous study of India, completed in 1030, Biruni's intellectual curiosity grew so insatiable that he found it impossible to accept anything as true unless he himself could verify it. He died around the year 1048. Much of Biruni's work is devoted to astronomy. At the age of seventeen he had created a meridian circle with one-half degree graduations, with which he was able to observe the meridian altitudes of the sun.

The first great wave of invasions from ethnic groups native to Asia proper followed the fall of the Ghaznavid dynasty. These invaders included the Turkish Seljuks, who converted to Islam in

the tenth century and were natives of the area around Lake Aral (the site of modern day Kazakhstan). Between 1037 and 1095 the Seljuks conquered the East Islamic countries (Persia, Mesopotamia, Asia Minor, Syria) and created from it the empire of the Great Seljuks of Persia (with residences in Isfahan and Tabriz), as well as the empire of the Seljuks of Rum in Asia Minor (today's Turkey, whose capital was Konya, ancient Iconium). This progression toward the Holy Lands set in motion the Crusades.

It was in the capitals of Merv and Nichapur that Omar Khayyam, the scholar and poet best known for his quatrains, reformed the calendar and edited a series of treatises that were to prove decisive in the field of mathematics. Born in Iran in 1048, Khayyam was invited by the Seljuk Sultan Malik Chah (1072-1092) to come to his capital, in Isfahan, in order to take charge of what could be called the first institutionally-run observatory in the Arabo-Muslim world. He was twenty-two years old at the time. Khayyam lived in this observatory for eighteen months, during which time he put together the *Astronomical Tables of Malik Shah*. In the field of mathematics, he wrote a commentary on Euclid's geometry and tackled the problem of root extraction in algebra, thanks to a method that was perhaps also used in Pascal's triangle.

It was under the rule of the Rum Seljuks that the city of Konya reached its historical zenith. Mas'ud I made it his capital. In the thirteenth century, the Persian poet Djalal al-Din Rumi (1207-1273) founded the order of Mawlawiyya, or whirling dervishes, there. In 1206, the first Seljuk hospitals (*dar al-Shifa'*) and madrasas were founded in Kayseri. The construction of other hospitals followed suit, in Sivas, Divrigi, Cankiri, Kastamonu, Konya, Tokat, Erzurum, Erzindjan, Mardin and Amasya. These hospitals admitted patients of all kinds and were staffed by surgeons, doctors, pharmacists, and oculists.

The Ayyubid period was marked by a virtual blossoming of hospital construction throughout the Arab Near East. Ibn Jubayr, who set out from Spain and crossed Syria between 1183 and 1185, noted one or two hospitals in most of the cities he passed through. Prince Nur al-Din (1146-1174), who successfully took on the Crusaders (by uniting Aleppo and Damascus under his sole authority), founded several madrasas and the renowned al-Nuri

hospital, in Damascus. The staff there kept a list of the patients' names and the amount of medicine and food that each required. A typical day for a chief physician at the Nuri hospital included general rounds, the prescription of medicines, treatment, and appointments with private clients. In the evening the doctor would return to the hospital for meetings.

The city of Aleppo also had two prestigious hospitals. The first was built under Nur al-Din, who endowed it with significant *religious endowments (waqf)*, the second under the Mamluk Prince Arghun.

Among the doctors who practiced in Syria was the surgeon Ibn al-Nafis, who died in 1288 in Cairo. His discovery of pulmonary circulation revealed an error committed by Galen. This important discovery was made some three centuries before the Europeans Servetus (1553) and Colombo (1559) succeeded in describing the circulatory system, thirty years after al-Nafis's ideas had reached the West.

Extensive hospital construction in the Near East continued throughout the Mamluk period (1259-1382 and 1382-1517, see B. N. Sehsuvaroglu). Thus, in 1285, the Sultan al-Mansur Qalawun had a prestigious architectural ensemble – composed of a madrasa, a mausoleum, and a hospital – constructed in Cairo. According to al-Maqrizi's description, it was perhaps the most skillful construction of its type seen in Islam to that time. The return on its endowment may have approached one million golden dirhams annually (the expenses of a typical hospital were between 200 and 600 dinars a month). Both men and women were treated. No one was turned away and there was no time limit to the length of treatment.

At the beginning of the thirteenth century the Mongols descended on the East Islamic countries. Genghis Khan (d. 1227), followed by his sons and grandsons, created a powerful empire, stretching across central, west, and east Asia. Apart from Mongolia, which was Genghis's homeland, the empire was divided into three vast and distinct parts: the Golden Horde (along the Volga river); the Yuan dynasty (created in China by Kubilai); and the Ilkhans, under the rule of Hulagu (located in Asia Minor, and to which Khwarezm, Persia, and Mesopotamia belonged, with residences in Persia, Tabriz, and Maragheh).

It was in Maragheh, for a period of twenty years in the thirteenth century, that astronomical observations were made in an

observatory built in 1259 by Hulagu, a grandson of Genghis Khan. Its construction was financed by a religious foundation. Virtually all the scientific disciplines were taught at this institution, and it also served as a meeting place where many of the great scholars of the Middle Ages gathered. It had a library containing some 400,000 volumes, and instruments such as astrolabes were manufactured there. The observatory was provided with state of the art scientific equipment: a quadrant with a 430 centimeter radius, armillary spheres, and others for measuring solstices, equinoxes, and azimuth circles. In the observatory, which was run by Nasir al-Din-Tusi, there worked more than twenty astronomers from all over the world: indeed one of them, Fad-Mun-Ji, came from China.

The oeuvre of Tusi is immense. Apart from his commentaries on the works of Greek mathematicians, he wrote his own mathematical and astronomical treatises that called into question some of Ptolemy's findings; he defended Avicenna's thought against its critics and composed several treatises on Ismaelian theology. Maragheh was a model that was imitated on several occasions. However, no observatory of the size of Maragheh was built before the fifteenth century, when the Timurid Sultan Ulug Beg did so.

Another large-scale editorial enterprise was undertaken by the Mongols in the fifteenth century at Tabriz, directed by the Vizier Rachid al-Din Fadl Allah. The most notable vestige of these labors is a Persian translation of a Chinese medical treatise.

Tamerlane (1336-1405) was the second great conqueror to come from Central Asia. He conquered Transoxiana, Persia, Mesopotamia, and a part of northern India. Asia Minor was taken after his victory over the Ottoman Sultan Bayazid I. During Tamerlane's reign, Samarkand became a sumptuous residence, while Herat developed into a center of the art of the miniature. One of his great grandsons, Babur, would found the imperial Moghol dynasty.

In the first half of the fifteenth century, the Sultan Ulug Beg (1394-1449), who was Tamerlane's grandson, founded a madrasa (an institute of higher learning) in Samarkand that stressed astronomical study. Four years later it had a large, state of the art observatory, vestiges of which still remain. It was a three story structure, with a giant sextant, indeed the largest astronomical

instrument of its type in the world: its radius was forty meters long. This Timurid prince, who was himself an accomplished astronomer, brought the best mathematicians of his time there: one of them, Ghiyath al-Din al Kachani, calculated the value of "pi" to the sixteenth decimal point. He was also probably behind the extremely precise astronomical calculations that show up in the astronomical table know as the *Zij-i-Gurgani*. After Ulug Beg's assassination Samarkand went into decline: in the sixteenth century the observatory was totally destroyed.

The Ottomans, who are also a Turkic people, reached Asia Minor toward the end of the thirteenth century. After the collapse of the Seljuk empire, Mehmet il Fatih (the Conqueror) took Constantinople in 1453 and made it the imperial capital. Gathering Greek, Latin and other manuscripts that had escaped destruction, he had them placed in the library he founded in Eski Saray. Ahmed III created at least five libraries and outlawed the exporting of rare manuscripts. Most of the libraries in the capital, which had previously been attached to mosques, were transferred to the library of Suleiman.

The first Ottoman *bimaristan* in Anatolia was the *dar al-chifa' de Yildirim,* in Brousse, which was founded in 1399. This institution was part of a special center that included a hospital, baths, and a resting place for travelers. It was not abandoned until the middle of the nineteenth century. Leprosariums were also built, in Edirne, Sivas, Kastamonu, and Kayseri.

North Africa played a leading role in the transmission of Arab knowledge to Medieval Europe, via Spain and Sicily. Kairouan, founded in 670, became the capital of Ifriqiya and reached its zenith in the ninth century, during the reign of the Aghlabid Emirs. This city, with a population of several hundred thousand, enjoyed a spirit of exceptional tolerance and became one of Islam's great intellectual centers, especially in the study of law and theology. Support from patrons attracted a large number of students, writers, and scholars. For example, at the close of the Aghlabid period, Ziyadat Allah III (903-909), summoned Ishaq al-Isr'ili (d. 955) to his court. A physician and philosopher, al-Isr'ili was a representative of Jewish neoplatonism: his works, inspired by Galen, spread throughout both the Muslim and Christian West.

His *Treatise on Fevers*, which was translated into Latin, Hebrew, and Spanish, was the first Arabic monographic on the subject.

In 909, the Fatimites – whom we discussed earlier in connection with developments in Egypt – eliminated the Aghlabids. It was during this period that the doctor Ibn al-Jazzar lived. His work, *Viaticum of a Voyager, Zad al-musafir*, reached Andalusia and was later translated into Greek, Latin, and Hebrew.

As for the Maghreb, the first large hospital we know of was built by the Almohad Sultan Ya-qub al-Mansur (1184-1199) in Marrakech, nearly a century before the construction of the famous hospital in Cairo. Al-Mansur was a great builder and was also able to attract to his court the most famous Hispanic doctors of the period: Ibn Tufayl, Ibn Rushd, Ibn Zuhr al-Hafid and his son. In the capital he had a magnificent medical facility built to serve both rich and poor foreigners; throughout his empire he had hospitals built for the mentally ill, lepers, and the blind.

Andalusia and Sicily, Bridgeheads toward the Christian West

Andalusia, which was a bridgehead toward the West, enjoyed a lively economic and cultural life throughout the Middle Ages. Along with Sicily under the Norman Kings, it played an essential role in the transmission of Eastern knowledge to the West. In 756, the last representative of the Omeyyad dynasty took Cordoba and founded an autonomous Emirate in which both Jews and Christians were permitted to maintain their customs and religion. During the reign of 'Abd-al-Rahman II (822-852) a new Arabic translation of Dioscoride's *Materia Medica* was begun. This translation was carried out by a team consisting of a monk from Constantinople who read Greek, some Christians knowledgeable about Latin, several Arab scholars and 'Abd-al-Rahman's Jewish doctor. The Emir had books brought from Iraq, including a famous astronomical work of Hindu origin. Astrologists, along with poets and scholars, played an important role at court. 'Abd-al-Rahman III (912-976), who took the title of Caliph in 929, took up residence in his new capital of "Madinat-al-Zahra'" ("City of Flowers"). In reg-

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ular contact with the Byzantine Emperor, he received books on Greek medicine from him. At the same time, scholars were sent to Baghdad to increase their knowledge. Merchants, pilgrims, and travelers brought still more books. As D. Jacquart and F. Micheau have shown, this was a period of enormous growth in all areas of knowledge. 'Abd-al-Rahman III and his successor, Hakam II (961-976), encouraged these developments. The role played by Hakam II in this regard was analogous to that played by al-Ma'mun in Baghdad a century earlier. As a patron of the sciences and philosophy, he built up a library whose holdings had little to envy the Abbasids. He also sent out representatives to acquire books for him throughout the entire Arab world. If not for the unfortunate lootings and ultimate destruction of the library under his successors and during the reconquest, it would have contained some 400,000 volumes.

Abu al-Qasim Khalaf al-Zahrawi, who lived in the tenth century and was known in the West as Abulcasis, was renowned both in the East and West. Best known as a surgeon, he in fact worked on a far wider scale. Apart from creating medicines, he also designed surgical instruments, such as one for the removal of tonsils.

In the eleventh century, Spain entered a period of civil wars. The last Caliph of Cordoba was deposed in 1031. The nation was fragmented into small antagonistic states, each of which led its own intense cultural life: this was the period known as "Las Reyes de Tayfas". At the same time, the Christian kingdoms embarked on a vast campaign of reconquest, taking back Cordoba and Seville. Henceforth, al-Andalus was reduced to the tiny kingdom of Grenada, where an ostentatious court held forth in the shadow of the Alhambra. The *reconquista* resulted in the eviction of the Muslims in 1492.

With only a few exceptions, all the great figures of the sciences and philosophy of Muslim Spain lived during the twelfth century. First under the domination of the Almoravids of the Maghreb, Spain later fell under the Almohad yoke. These powerful sovereigns extended their domination over most of the Muslim West, making Cordoba their capital. It was at this time that a multitude of scholars, philosophers, and doctors flocked to the southern cities of the Iberian peninsula: for instance, Abu Marwan 'Abd al-

Malik Ibn Zuhr, known in Latin as Avenzoar, took up residence in Seville. One of his medical works, dedicated to Ibn Rushd, was translated into Hebrew and Latin.

Although Ibn Rushd, whom we know as Averroes, was born in Cordoba in 1126, he spent most of his life in Marrakech, Morocco, where he died in 1192. Averroes was a physicist and logician, astronomer, observer and theoretician whose greatest influence was on the development of Western astronomy. Averroes also co-authored a general medical encyclopedia with his friend, the physician Ibn Zuhr. However, it was by order of the Almohad sovereign Abu-Ya'qub (1163-1184) that the young Averroes drew up his commentaries on Aristotle which so startled the West and later earned him the Latin nickname of "The Commentator." In his commentary on Aristotle's *Metaphysics*, which he considered to be the greatest and ultimate authority on philosophy, Averroes argued in favor of a non-Ptolemyan, Aristotelian system of astronomy, although he did so without blindly parroting the Greek philosopher's ideas. In this sense, it can be said that he introduced the West to the principle of philosophical debate. The Jewish theologian and doctor Ibn Maimun (that is, Maimonides, b. Cordoba 1135, d. Fustat 1204), who was educated in the East and was a product of the same philosophical milieu as Averroes, also took up this critique of Ptolemyan astronomy. Ibn Rushd's ideas exercised a profound influence on Western Medieval thought and earned him considerable renown in his own time.

Much of the scientific heritage reached Europe via Sicily and Spain. In Sicily, the Norman court at Palermo was a veritable cauldron of cultures. The island, after having experienced four centuries of Byzantine domination and two centuries of Muslim occupation, was reconquered by the Normans between 1061 and 1092. Frederick II took possession of the island in 1194, at which time it became a crossroads of men, products, and ideas among the Latin, Arab, and Greek civilizations.

It was in large measure thanks to the work of a translator known as Constantine the African, nicknamed the "master of the East and the West," that medical knowledge reached Europe. Born in Carthage, he seems to have studied liberal arts and medicine in Cairo. He also probably traveled to India and then to

Ethiopia, where he took up the study of Hebrew, Syriac, Chaldeen, Greek, Ethiopian and even Indian languages. Noting the paucity of medical texts in Western languages, Constantine decided to study medicine and gather as much medical literature as he could. Remaining in Tunis for three years to engage in these activities, he returned to Sicily where he was welcomed to Salerno by the Norman Duke Robert Guiscard. He then entered the monastery at Monte Cassini and became a monk. He died around the year 1087. One of his most famous translations is known as *Eisagoge*, which is a translation of fragments from Hunayn ibn Ishaq's *Masa'il fi-al-Tibb.* It was transcribed and annotated many times between the twelfth and fifteenth centuries. His *Pantegni* is a translation of virtually the complete works of 'Ali ibn al-Abbas al-Majusi. These two works had a substantial impact on the development of medicine in general. The works of Ishaq al Isra'ili, known as Isaac, and of Hunayn Ibn Ishaq, known as Iohannitius, also deserve mention. Among the works of Ibn al-Jazzar that Constantine rendered in Latin, the most important was the *Viaticum*, a translation of *Zad al-Musafir*. Constantine's translations, which were used at the medical school of Salerno in the twelfth century, provided the foundation for Arab medicine in Europe. Salerno maintained its dominant position in southern Italy until the thirteenth century. However, the sack of the city in 1194 by the imperial troops marked the beginning of its decline. Constantine must be credited with having enriched the high European Middle Ages with his translations of the most important Greco-Arab works.

Al-Idrissi was one of the scholars attached to the court of Sicily. Born in the year 1100 at Ceuta, Morocco, he was educated at Cordoba. Although he died in his native city in 1166, he spent the greater part of his life outside of Islamic regions. At the age of sixteen, he traveled to Asia Minor, Morocco, Spain, the coast of southern France, and even to England. The Norman king, Roger II, invited him to take up residence in Palermo, which was a meeting point of Arab and European cultures. The sovereign entrusted him with the job of creating a relief map made of silver. Envoys were even dispatched to gather the necessary funds, and the project was completed as planned.

Frederick II of Hohenstaufen, German Emperor of the Holy Roman Empire, spoke nine languages, including Arabic. He was a precursor of the princes of the Western Renaissance. In constant communication with Arab scholars, he increased his contact with them after being excommunicated from the Catholic Church by the Pope, sending off questionnaires, often of extreme complexity, to Egypt, Syria, Iraq, Asia Minor, Yemen and Morocco. He also kept a menagerie and wrote a famous treatise on falconry which combined theoretical and practical knowledge. Jacob Anatoli translated the works of Ptolemy and Averroes for him. The emperor's astrologer, Michel Scot (b. 1235), was another "cultural bridge," being a Scotsman educated in Spain. From Toledo he brought back for his master Aristotle's *Zoology*, as well as *De Caelo et Mundo*, accompanied by Averroes's commentary. However, it was another man who dominated this cosmopolitan intelligentsia: Leonard Fibonacci (Leonardo da Pisa), the greatest mathematician of the Middle Ages. In 1192, he accompanied his father on a consular mission to Algeria. There he studied arithmetic, the Arabic language, and the techniques of commerce before setting out for Egypt, Syria, Greece, and Sicily in search of books. Returning to Pisa in 1202, he composed his *Liber Abaci*, a compendium of all the knowledge he had acquired in the East. In it he took up the Indian number system, the multiplication of integers, addition, subtraction, division, the multiplication of integers with fractions, the techniques of commerce, currency, etc.

In 1266 Sicily was given to Saint-Louis's brother, Charles d'Anjou. In 1279, Faradj ben Salem, a Jew from Agrigento, completed his translation of Razi's *Kitab al-Hawi*. A deluxe transcription of it (five volumes, in folio) was delivered to the sovereign in 1282. Eight scribes and two painters took part in the preparation of this work. It is worth noting that the translators often privileged works describing practical experimental activity, such as clinical cases and the like.

Translations and Techniques: the Introduction of Islamic Science in the West

In the twelfth and thirteenth centuries, Toledo became an important center of learning (see the articles of D. Jacquart). It was there

that al-Zarqali (Latin Azarquiel) perfected the astrolabe and put the finishing touches on the *Toledan Tables* (translated in the thirteenth century at the court of Alphonse X), which would serve as the basic tools of Western astronomy until Copernicus. At the same time, thanks to the presence of numerous manuscripts, and of Mozarabs and Arabic-speaking Jews, Toledo became the site of unparalleled activity in the realm of translation, Gerard of Cremona (1114-1187) being its most famous representative. Apparently born in Lombardy, Gerard traveled to Toledo to learn Arabic and served as the cathedral's Canon in 1157. He devoted his life to the translation into Latin of Arabic works of philosophy, mathematics, the occult sciences, and medicine. He translated the Baghdad astronomical treatises, written in the eighth and ninth centuries (Al-Farghani, Thabit Ibn Qurra), as well as works of Aristotle, Galen, Euclid, Farabi, al-Kindi, and Khwarizmi. He made known to the West the works of Razi and especially Ibn Sida, who deserves special mention here. Gerard translated *The Canon of Medicine*, which was extremely popular and served as the basic medical textbook in the Medieval universities. Having been transcribed numerous times in Medieval manuscripts, it was printed for the first time in its entirety in 1473, at Milan. Twelve editions of it appeared before the end of the fifteenth century, some sixty more between 1500 and 1674. It is possible that the Parisian teachings of the Mendicants played a decisive role in the spread of Avicenna's *Canon*.

Albert the Great (d. 1280), proclaimed the patron saint of Christian scholars, was one of the most illustrious members of the Dominican Order. Albert was a giant of the thirteenth century in the natural sciences, philosophy and theology. After studying in Italy, he taught at the universities of Hildesheim, Strasbourg, and Paris, where he discovered Greek and Arab works that had recently been translated into Latin. His efforts at making these works known throughout the West brought a wave of hostility from the theologians at the University. However his disciple, Thomas Aquinas, did not hesitate to integrate some of his demonstrations into Catholic theology.

Like Avicenna, Abalcusis wrote an enormously influential treatise, which served as a foundation for many of the key surgical works written after the thirteenth century. A fourteenth century

translation of his works into Languedoc made it possible for non-Latinists to gain access to his thoughts. Among the great translators Abélard de Bath, future tutor of Henry II of England, deserves mention. He translated many scientific works into Latin, including an Arabic version of Euclid's *Elements* that remained authoritative among geometers for centuries. Most of the thirteenth century translators were drawn to the works of Arab authors of the twelfth century who lived in the West: Maimonides, Averroes, Avenzoar.

Another cultural bridge, Raymond Lulle (1231-1315), through frequent contacts with three religions, became such a master of Arabic that he was able to write several treatises in this language. Their aim was to convert Muslims to Christianity. This Franciscan Brother was even able to convince the Pope to establish Arabic, Aramean, and Hebrew-language schools in Rome, Bologna, Paris, Oxford and Salamanca.

What, concretely speaking, did all this translation bring the West? A huge body of practical and theoretical knowledge in a wide variety of fields. J. Vernet has offered us a panoramic view of it in his book, *Ce que la culture doit aux arabes d'Espagne*. The evolution of botany in the Middle Ages was based on the works of Aristotle and Theophrastus, which were originally translated into Arabic by Ishaq Ibn Hunayn and later revised by Thabit Ibn Qurra. They were translated into Latin in 1227 by Alfred de Sareshel. Developments in medieval zoology were based on Arabo-Latin translations of the works of Aristotle. *De naturis animalium*, translated into Arabic by Ibn al-Bitriq, was translated into Latin in 1220 by Michel Scot, who also translated Avicenna's commentary. This version served as the foundation for Albert the Great's *Book of Animals*.

In the medical field, the translation of the Avenzoar's works revealed that chicken pox immunizes the sufferer against reinfection. Averroes's *Kitab al-Kulliyat* was translated under the title *Colliget*. It is composed of seven books, treating anatomy, pathology, semiotic, therapeutics, hygiene, and medication. It is believed that Michael Servetus, Europe's supposed "discoverer" of pulmonary circulation, knew the works of the Damascus doctor Ibn al-Nafis, who had propounded the same theory two hundred years before in his commentary to Avicenna's *Anatomy*.

In the field of technology, A. Husher, in his work *The History of Mechanical Invention*, asserts that the use of aeolien energy probably originated in Central Asia and that it had already been described by Mas'udi and Istakhri at Sistan. This technology is found in the eleventh century in Spain, in the year 1180 in France, and around 1270 in England. Water clocks, which would be found in the West only later, are already attested in the reign of Harun al-Rachid. Gunpowder was apparently introduced to Spain in the thirteenth century. It was used by the Grenadin Sultan Isam'il in 1324. After this date, mentions of gunpowder increase markedly: it is found in France and Italy by the fourteenth century.

One of the most important contributions made to culture by the Arabs was in the realm of marine travel and navigation. The Arabs transmitted to the West diverse elements of naval architecture (the Latin sail, sternpost rudder, and techniques of ship construction); astronomical techniques (the determination of coordinates, latitude and longitude, the use of astrolabe, quadrant and compass); and geographical aids (the use of nautical charts, beacons, portolanos). This progress made possible the era of discoveries: the tables that Christopher Columbus used on his voyages were derived from Ibn al-Kammad's.

In the area of applied technologies, Muslim agricultural products were widely disseminated in the West: the orange tree, which went from Palestine to Spain via Syria; and sugar cane, which the Muslims imported from India and which reached Europe via the Crusades; we can also mention cotton, which also came from the Arab world.

In the area of arts and culture, paper reached Cordoba in the ninth century, then Jativa in the twelfth, where it was exported both to the West and East. Thus, for instance, Alphonse X used Toledan paper. Centers of paper production also arose in Italy, in Fabriano and Ancona, and later in France, in the cities of Troyes in 1348, Nuremberg in 1390.

Silk seems to have been an Andalusian monopoly until 1146. At that time Roger II introduced its production to Italy by bringing Greek workers to Palermo. After the fourth Crusade Venice took it up. Knowledge of silk production then spread throughout Europe.

As for the arts of earth and fire, Marthe Bernus has pointed that it was under the Abbasids, around Baghdad in particular, that one of the great inventions of the Muslim potters was made: the tech-

nique of metallic luster (the luster is created by the application of a thin coating of metal – oxides of copper and silver – which is laid on the fired piece while it is cooling, which gives it a golden tint). A host of ninth century sites, including Samarra, Suse, and Fostat, offer abundant examples of this kind of pottery, which would later reach Transoxiana, Sind, Algeria, and Spain. This procedure was transmitted to Italy, by way of Spain, and is practiced even today.

Islam has even enriched the Western vocabulary to some extent: damask comes from Damascus, muslin from Mossoul, the French word for cobbler, "cordonnier," from Qurtuba, and the French word for rug, "tapis," from Atabi. Muslims were ahead of Europeans in the extraction of minerals and dyes, in the production of tempered steel for weapons, and in the techniques of commerce. Words like caravan, from *qarawan*, tariff, from *ta'rifa*, divan, from *diwan*, and the French word for store ("magasin"), all come from Islamic sources.

The contribution of Islam to Western civilization in the area of literature has perhaps not been sufficiently appreciated. Cerulli, however, in his *Libro de la Scala* (Vatican, 1969), points out that the "Mi'raj," or ascension of the Prophet, and the mysticism of Ibn 'Arabi, inspired both Dante and Raymond Lulle. Renan, in his book on Averroes, explains how poets like Petrarch knew the Arab poets, although without sharing their ideas.

In a recent study entitled *Penser l'art islamique*, the eminent historian of Muslim art Oleg Grabar discusses the formation and evolution of Muslim art, which he ascribes to "the encounter of each locus of culture (Byzantine, Persian, etc.) with Koranic revelation," and then goes on to show that the chief contributions of Islam were in the fields of architecture, calligraphy, and geometry. In conclusion, he writes that, "the originality of traditional Islamic art was rooted in its openness to all tastes and its ability to satisfy the aesthetic needs of diverse communities."

Muslim Influence on the European Centers of Learning

In the twelfth century, when the totality of Greek knowledge, enriched by Arabo-Muslim science, reached the West, the univer-

sities of Paris and Oxford, which had only recently been created, were the first to be affected. Among the Dominicans and Franciscans who taught there were Robert Grosseteste and his student, Roger Bacon, both of whom were well acquainted with the Arabic works translated into Latin, especially those of Ibn al-Haytham. The reading of Constantine the African's translations spread to Chartres in the first half of the twelfth century. The works of Guillaume de Conches, which were inspired by the *Pentegni* and the *Eisagoge*, were tremendously popular during the Middle Ages. The Arab texts, once they became known, were the subject of various commentaries and controversies. Avicenna, in his role both as philosopher and physician, played the role of mediator between Aristotle and Galen, whose work was enthusiastically received in Bologna, Montpellier, and Paris. By the end of the Middle Ages, Avicenna's *Canon* exerted a dominant influence at the University of Padua (where both Galileo and Vésale spent time). In 1405, at Bologna, scientific theory revolved around two Greek authors: Hippocrates and Galen, and two Arab authors, Avicenna and especially Averroes.

What is the West's Real Cultural Identity?

According to Roshdi Rashed: "By retracing the path of rational activity followed by Arab scholars seeking to answer questions of a scientific order, we can show how the assimilation of the Hellenistic tradition, based on new interests, allowed a reorientation of scientific knowledge within new perspectives that would be taken up again and deepened during the European Renaissance."

The knowledge that formed the basis for the Western Renaissance came from several sources: first from Rome. "The respect that the Romans showed the Greeks is striking," Colin Ronan has written. "Down to the very last days of the Western Empire, the works of Plato, Aristotle, and Homer were taught and presented as an ideal model of clarity of thought and excellence of composition ... Thus, Rome played a crucial role in keeping Greek ideas alive, a role that the learned men of the Renaissance greatly appreciated a full millennium after the definitive fall of Western Roman Empire."

Then from Byzantium. For Jean Théordorides, "To their great credit, the Byzantine scholars preserved countless Greek and Eastern works which were systematically copied, commented upon, annotated, translated, even illustrated. In this way, they contributed to the spread of Hellenic science both to the East – to the Syrians, Persians and Arabs, after the exodus of Nestorian and Neoplatonic scholars – and to the West, first during the Crusades and then again after the fall of Constantinople, when Byzantine scholars reached the West with their books and manuscripts. The arrival in Italy of some of these scholars is rightly considered to be a contributing factor to the advent of the Renaissance."

Finally, from the Arab-Muslim world through the intermediary of Spain and Italy. This is how one of the great contemporary historians, Gabriele Crespi, in his conclusion to *Muslim Europe*, frames the matter of the Arab intellectual contribution to the West: "In this work of transition and creation of a new culture, Muslim Spain played a leading role in the intellectual history of Medieval Europe. The contribution of the Crusades to the introduction of the science, philosophy, and wisdom of the ancient world has been overemphasized. It was Andalusia that played the crucial mediative role." He concludes on a more general note: "Islam's influence on the formation of Medieval Western culture was therefore decisive. For its part, the Christian world was able to experience forms of intellectual and artistic life far different from its own, sometimes even entering into dialogue but in any event always learning because the transfer of knowledge went in one direction only: from the East to the West."

The idea that the Crusades played a major role in the transfer of ideas through translations between East and West must be rejected. Their contributions tended to be of a purely military nature (falconry, Greek fire), while from the other side the Crusaders were most impressed by the structure of Eastern charitable institutions, social traditions, and the like.

This lack of proper appreciation of the true importance of the Islamic contribution to Western culture is one of the conscious or unconscious causes for the frustration felt by many Muslims in regard to the West. It's as if this transfer of knowledge and technology from the East to the West had been considered, since the time

of the Crusades, as a kind of war booty, torn directly from an enemy's hand, and not taken from a culture worthy of dialogue and exchange. Yet Albert the Great and Kepler expressed nothing but the greatest respect for the likes of Avicenna and Ibn al-Haytham. Why shouldn't their example be followed? "Bayt al-Hima" is not merely an episode in the history of humanity: it is a state of mind. Let us hope that one day, people of all religions and cultures will find themselves gathered together in new "Houses of Wisdom."

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