European Review, Vol. 16, No. 2, 169–181 © 2008 Academia Europæa
doi:10.1017/S1062798708000161 Printed in the United Kingdom

The Contribution of the Jews of Spain to the Transmission of Science in the Middle Ages

MARIANO GOMEZ-ARANDA

Instituto de Lenguas y Culturas del Mediterráneo y Oriente Próximo, CSIC, Albasanz 26–28, 28037 Madrid, Spain. E-mail: aranda@filol.csic.es

The Jews of Spain in the Middle Ages played an important role in the transmission of Graeco-Arabic learning by translating, or participating in translations, of scientific texts. They also composed original works on mathematics, astronomy, astrology and medicine in which they adapted the theories of the ancients for their own time. Science was used by the ruling powers as an element of prestige, and by the Jewish scientists as a way to obtain a high social status. The policy of cultural sponsorship of Muslim caliphs, as well as of Christian kings, was fundamental in the process of transmission of the Greek sciences to the Western world. The School of Translators of Toledo is an example of this process. The astronomical theories developed by Jewish scientists at the end of the 15th century played an important role in the Spanish and Portuguese discoveries of the 16th century. Their knowledge of astronomy, astrology, mathematics, and medicine was also used by the Jewish intellectuals to provide a rational and scientific support for the Jewish religion and tradition, as is reflected in the interpretations of the Bible by medieval Spanish Jewish authors.

Introduction

In his introduction to his translation of *Ibn al-Muthanna's Commentary on the Astronomical Tables of al-Khwarizmi*, the Jewish scientist, exegete, and Hebrew grammarian Abraham ibn Ezra (1085–1164) presented his own interpretation on the process of transmission of Hindu and Greek astronomy to Islam, and on the role of the Jews in this process. Ibn Ezra's account may be summarized as follows,

> The first Abbasid caliph (ca. 750) had heard of the sciences of the Indians and wished to have some of their books translated into Arabic, for profane sciences

> were unknown to the Arabs at that time. He was not sure that this was religiously permissible until the angel of dreams assured him of it. He sent for a Jew and told him to go to Ujjain (in West Central India) to bring back an Indian scholar, which by some subterfuge the emissary managed to do. The Jew served as an interpreter between the Indian, Kanka, and the Arab who translated the book of Indian astronomy, containing the tables of the seven planets, the rising times of the zodiacal signs, the arrangements of the astrological houses, and some other data relevant for the practice of astronomy.[1]

This account illustrates the main contribution of the Jews to the transmission of sciences in the Middle Ages. The Jew in the story acts as an intermediary between two cultures, the Indian and the Arab, and participates in one of the most important activities for scientific transmission, translations. Translations of scientific works from Greek into Arabic, and from Arabic into Hebrew and Latin served as the most effective method for the reception of Graeco-Arabic learning and its integration in Western culture. This process began as early as the tenth century and culminated in the famous so-called 'School of Translators of Toledo,' in which Jewish translators played an important role. The Jews also composed, in Arabic, Hebrew or Latin, original works on mathematics, astronomy, astrology and medicine, in which the theories developed by the Greeks and the Muslims were adapted to the necessities of their own times. In this sense, the medieval Jewish scientists can be considered more as transmitters than truly as innovators of science. However, this does not imply that their scientific work lacks originality. What is new and original in medieval scientific works written by Jews is how they were able to apply and adapt the scientific theories of the time to the knowledge and practice of their own religion. For instance, theories on the circular motion of the planets and the fixed stars around the earth were used to determine the Jewish calendar and fix the exact dates and times of feasts. The knowledge of medical principles on the effects of foods on health was very valuable in order to understand the scientific basis of the Jewish religious laws and precepts concerning food. Scientific theories also helped to understand and explain the Biblical text, and provided Jews with the rational arguments necessary to justify their own religion and traditions in controversies with Muslims and Christians.

Science in the Middle Ages was also considered an element of power. Medieval kings, caliphs or sultans promoted the development of science in their own territories because it contributed to their prestige and splendour, and raised them above their enemies. Jews soon realized that, by collaborating with Muslim or Christian powers in scientific and cultural matters, they were able to gain a higher social status. There are several examples of outstanding Jewish scientists who worked for Muslim caliphs or sultans and Christian kings as astronomers, astrologers, physicians, and translators.

In what follows, I will review the contribution to the transmission of science of the most important Jewish scientists of the Iberian Peninsula in the Middle

Ages, and analyse their historical circumstances and the motivations that made this transmission possible.

Hasday ibn Shaprut and the translation of Dioscorides' *Materia Medica*

One of the most prominent Jewish scholars to contribute to the transmission of science by translating relevant texts of Greek medicine was Hasday ibn Shaprut. He lived in Cordoba in the tenth century and worked for the Umayyad caliphs Abd al-Rahman III and al-Hakham II. Ibn Shaprut was responsible for the translation into Arabic of the famous book of Dioscorides, *Materia Medica*. This was the most important treatise on pharmacology written in Greek in ancient times, and was one of the monumental achievements of Hellenist medicine.

Constantine VII, Emperor of Byzantium, wanted to sign a treaty of friendship with the caliph Abd-al-Rahman III in order to stop the expansion of the Fatimid caliphs of Egypt. The Emperor sent a delegation to Cordoba which was welcomed by Abd-al-Rahman III in his palace in Medinat Zahara with all kinds of honours. Very little is known of the conditions of this treaty, but the chronicles give many details of the gifts presented by the Byzantine Emperor's delegates to the caliph. The Muslim chronicler Ibn Yulyul describes the scene as follows,

> Abd-al-Rahman received from the Emperor of Constantinople – in the year 948 I believe – a letter accompanying gifts of great value; among them was Dioscorides' treatise, illustrated with magnificent Greek miniatures and written in Greek. The Emperor wrote in his letter to Al-Nasir: 'You will only be able to benefit from Dioscorides through a translator accustomed to Greek and familiar with the properties of these drugs. If you should find in your country a person who possesses both conditions, this book will be of maximum utility to you.' […] In Cordoba there was no one capable of reading Greek, so Dioscorides' treatise remained in Abd-al-Rahman's library waiting for an Arab translation. The caliph asked the Emperor to send someone who spoke both Greek and Latin who would teach these languages to his slaves so that they could become translators. The Emperor sent him a monk called Nicholas, who arrived in Cordoba in 951. At that time there were several doctors in the city who were investigating, researching and desperately trying to find the Arab equivalents of the names of the drugs in Dioscorides' treatise. The most interested and diligent of all the doctors was the Jew, Hashday ibn Shaprut, who was eager to please Abd-al-Rahman in this matter. The monk Nicholas became his most intimate and appreciated collaborator. In this way, he was able to expound the names of the drugs in Dioscorides' work which were unknown until that time.[2]

The information of this chronicle can help us to appreciate the importance of this translation. First, a scientific treatise is used as an element to forge political bonds between two empires, Byzantium and al-Andalus. This epitomizes the idea

https://doi.org/10.1017/S1062798708000161 Published online by Cambridge University Press

that, in the Middle Ages, science was considered a political factor which contributed to the prestige of the powers that possessed it. Second, it shows how the Jews became important in the court of the caliphs in Al-Andalus and how they were willing to collaborate with those having power. Third, the translation of Dioscorides' work by a Christian monk and a Jew working together is an example of the most common method of translation in medieval Spain: the collaboration of experts in different languages and religions in the process of translation.

Dioscorides' *Materia Medica* had already been translated in Baghdad in the eighth century by the well-known Christian translator Hunayn ben Ishaq. However, this first Arabic translation contained a large number of plants with strange and unfamiliar names that were impossible to identify in Spain; some names of plants were not even translated but only transliterated. The merit of Hasday ibn Shaprut was that he could identify a large number of plants in the Greek book of Dioscorides, and find equivalents in Arabic. Some modern scholars therefore consider Ibn Shaprut not to have made a completely new translation of Dioscorides' work, but to have revised the earlier translation by Hunayn ben Ishaq by adapting it to the linguistic and geographical conditions of al-Andalus.[3] Dioscorides' *Materia Medica* was later translated into Latin and was used in popular medicine in the Middle Ages.

Hasday ibn Shaprut also became famous as a physician. In Cordoba, he received King Sancho of Leon who was ill due to excessive obesity, and succeeded in healing him. With the practice of medicine, Ibn Shaprut contributed to the prestige of the caliphate of Cordoba. For him, as for other Jewish physicians, the practice of medicine served to gain him a higher social status and to curry favour with the political authorities.

The prestige of Hashday ibn Shaprut, as well as of other Jewish physicians, was recognized by Muslim authors. In his *Tabaqat al-Umam*, Sa'id al-Andalusi dedicates a chapter to Jews that were prominent in the sciences in al-Andalus. On Hashday ibn Shaprut, he says that 'he was skilled in the practice of medicine, very learned in the legal science of the Jews, and he was the first to open up for those of them who were in al-Andalus their legal and historical and other sciences.'[4] Sa'id al-Andalusi also mentions other Jewish physicians and grammarians, such as Jonah ibn Janah, of whom he says that 'he wrote a fine work on the simple medicaments and on the definition of the amounts to be used in medical treatment according to weights and measures.'[5]

The emergence of medieval Hebrew science

With the demise of the Caliphate of Cordoba at the beginning of the 11th century, Jewish science did not disappear. On the contrary, in the period of the *taifa* kings, with conflicts raging between the different kingdoms, Jewish physicians,

astronomers and astrologers worked in the service of the various kings, and contributed to their prestige and splendour.

With the arrival of the Almohads in the Peninsula and their policy of intolerance toward Jews and Christians, many Jews emigrated to Christian territories in the Peninsula or to other lands far away from the danger of the Almohads. The Jewish scientists who emigrated carried with them the scientific knowledge they had acquired in al-Andalus and thus contributed to the spread of science in Western Europe. In the process, Jewish scholars abandoned Arabic and adopted Hebrew and Latin as vehicles for expressing secular and scientific ideas.

Abraham bar Hiyya (ca. 1065–ca. 1140) was a pioneer in the rise of medieval Hebrew science. He was the first medieval Jewish intellectual to write in Hebrew for a Jewish audience about astronomy and astrology in the framework of Graeco-Arabic science. His astronomical work *Surat ha-Ares* (*The Shape of the Earth*) is a geography in which he explains the theory of the seven climes, a traditional division of the terrestrial globe into climatic zones, invented by the Greeks and transmitted in Hebrew, Arabic and Latin treatises in the Middle Ages. This work long remained the chief source of geographical knowledge among Jews. In his work *Heshbon Mahlakhot ha-Kokhavim* (*The Computation of the Motions of Stars*), Bar Hiyya expounded the Ptolemaic astronomical system in Hebrew. He also composed a mathematical treatise dealing with practical geometry, *Hibbur ha-Meshiha ve-ha-Tishboret* (*Treatise on Mensuration and Calculation*), and the first Hebrew encyclopaedia of science, *Yesode ha-Tevuna u-Migdal ha-Emuna* (*The Foundations of Understanding and the Tower of Faith*). He further wrote the *Sefer ha-Ibbur* (*The Book of Intercalation*), the first Hebrew work on the Jewish calendar. He is the author of *Megillat ha-Megalleh* (*The Scroll of the Revealer*), an astrological history of the world designed to foretell the exact date of the coming of the Messiah by means of Scriptural data.[6] The use of astrology for this type of prediction was in great demand in times when the Jews suffered from persecution. Bar Hiyya collaborated with a Christian, Plato of Tivoli, in translating scientific works from Arabic into Latin. Amongst these figured Claudius Ptolemy's *Tetrabiblos*, a handbook for astrological prognostications that exerted a powerful influence on Jewish, Islamic and Christian astrological traditions.[7]

In the beginning of the 12th century, Moses ha-Sephardi, living in Christian Spain, converted to Christianity and assumed the name Petrus Alphonsi. He travelled to France and England, where he engaged in astronomy and medicine and the translation of Arabic works on science. He taught Christian scholars how to predict eclipses by determining the positions of the Sun, the Moon, and the ascending and descending nodes and also informed them of the different chronological systems used by Egyptians, Jews, and Romans, and of the discrepancies between the Indian and Greek descriptions of the limits of the zodiacal signs.[8]

Abraham ibn Ezra: mathematics, astronomy, astrology, and biblical interpretation

Abraham ibn Ezra was born in Tudela (Navarra) at the end of the 11th century. He was a Spanish Jewish intellectual imbued with Arabic culture, who left al-Andalus, travelled around the Christian countries, and in his wanderings through Italy, France and England, spread the scientific and cultural learning that he had acquired during his youth in al-Andalus.

Abraham ibn Ezra devoted his scientific works to what he called 'the wisdom of stars', a term that embraced mathematics, astrology and astronomy. He considered that secular sciences are like 'rungs in the ladder that leads to True Wisdom.' In his *Sefer Yesod Mora* (*The Book on the Foundation of Awe*), he recommends the knowledge of linguistics and grammar in order to understand the meaning of Scripture and to follow the path to God. He also says that, in order to fulfil God's commandments, especially those referring to the festivals and the fixing of the calendar, it is absolutely necessary to study astronomy and to learn the orbits of the Sun and the Moon. He also recommends the study of psychology in order to understand 'the five ways in which a human being's soul is similar to its creator.'[9] Abraham ibn Ezra is the best example of how secular sciences were assimilated and integrated into the religious thought of the medieval Jews. His *Sefer ha-Mispar* (*Book of the Number*) is an important contribution to the development of mathematics in Western Europe, and one of the fundamental texts for the historiography of mathematics in the Middle Ages.[10] It is an arithmetical treatise, in which Ibn Ezra explains, for the first time in Hebrew, the decimal place-value system of numeration invented by the Indians and transmitted by al-Khwarizmi's *Treatise on Calculation with the Hindu Numerals* in the Muslim world. He also explains the four basic operations of addition, subtraction, multiplication and division as well as the extraction of the square root. This treatise is one of the first to introduce the arithmetic of the Arabs to Latin Europe, together with a presentation of the decimal positional system.[11] It is contemporary with another Latin version of al-Khwarizmi's mathematical treatise entitled *Liber Ysagogarum Alchorismi*.[12]

As Ibn Ezra pointed out, the knowledge of the precise movement of the stars in heaven was basic to determine the Jewish calendar and accurately fix the dates and times of feasts and Sabbaths. He wrote several treatises designed to teach the use of scientific tools and instruments, such as astronomical tables and the astrolabe, and to explain the astronomical foundations of the Jewish calendar. In his *Sefer ha-Ibbur* (*The Book of Intercalation*), he deals with the controversial question of the length of the solar year, and presents the views of several astronomical schools. He concludes that, since Greek and Arabic astronomers were unable to determine exactly the length of a year, Jews should only trust in

the opinion of the sages, which is based on tradition and is one of the pillars of Judaism. This is an example of how Ibn Ezra tried to harmonize the principles of the Jewish religion with the scientific theories of his time, and how he decided in favour of Judaism when that harmonization was not entirely possible. His translation of *Ibn al-Muthanna's Commentary on the Astronomical Tables of al-Khwarizmi* is remarkable in the history of medieval science, as the Arabic original is lost and only Ibn Ezra's translation has been preserved. This treatise presents the influence of Hindu astronomy on the procedures and methods to elaborate astronomical tables, which, until the time of al-Khwarizmi, followed the rules of Greek-Ptolemaic astronomy. In this sense, Ibn al-Muthanna's commentary is also an attempt to harmonize the Hindu and Ptolemaic sources of Arabic astronomy.

Ibn al-Muthanna's interest in astronomy and astrology is connected with the activity that made him famous in his own time and gave him an important place in the history of Jewish thought: the interpretation of the Bible. In his introduction to his commentaries on the Pentateuch, he affirmed that 'reason is the foundation [of the Torah], because the Torah was not given to those who have no knowledge, and the angel [i.e. mediator] between human being and God is his intelligence.'[13] In his commentary on Ecclesiastes, he stated that this biblical book deals with laws of nature, although these laws are not explained in the book in a clear and evident manner, because the purpose of its author was not to teach science. Consequently, the object was to uncover the scientific theories hidden in the biblical text and show that the knowledge provided by the Bible conforms to that provided by the profane sciences. Abraham Ibn Ezra found in Ecclesiastes allusions to several theories of medieval scientific thought such as the four elements that compose all created beings, the peculiarities of the movements of the sun and the other heavenly objects around the earth, the sublunar world as a model of the superior world, the dependence of time and space on the stars' movements, and the dependence of a person's destiny on the position of stars and planets in heaven.[14]

Ibn Ezra believed in the influence of the stars on the great events in the history of humanity. For example, he believed that the conjunction of the planets announced the origin of the great religions, and the liberation of Israel from Egypt. The idea that each nation is ruled or governed by a planet was typical of medieval astrology. The Jews were under the influence of Saturn, the highest planet and the farthest from the earth because it is placed at the seventh sphere. Saturn was also considered the most malignant of the seven planets, and was associated with destructions, illnesses, exile, poverty, fears, deaths, and other terrible things. In medieval astrology, each day of the week was governed by one of the seven planets, and each planet exerted an influence on the human activities performed on its own day. But how are all these ideas connected to the Biblical text and how can these concepts be integrated into Jewish religious thought?

In his commentary on Exodus 20:13, Ibn Ezra explains the reasons for the Ten Commandments. The fourth commandment says 'Remember the Sabbath day, and keep it holy,' which according to the Jewish tradition means that one should not do any kind of work whatsoever on the Sabbath. How does Ibn Ezra relate the ideas of Saturn as a wicked planet and as the planet influencing the Jewish people and governing the Sabbath? This is his explanation:

> The fourth statement [Commandment], the statement about the Sabbath, corresponds to the sphere of Saturn. The astrologers tell us that each of the planets has a certain day in the week in which its power is manifest. […] They say that Saturn and Mars are harmful stars. Therefore harm befalls anyone who begins any work or sets out on a journey when one or the other dominates. […] It is therefore unfit for one to occupy himself on Saturday with everyday matters. On the contrary, one should devote himself on this day to the fear of God.[15]

Ibn Ezra tries to give a 'rational' explanation of the prohibition to work on Saturday by connecting this religious commandment with the medieval idea of the astrological influence of the planet Saturn: it is inappropriate to do any work on Saturday because Saturn's influence on this day will lead to terrible consequences.

Ibn Ezra used Hebrew, and specifically Biblical Hebrew, for the transmission of science to the Jewish communities in Europe. As S. Sela has pointed out, the transition from Arabic to Hebrew was actually the passage from a language which had already proved itself able to accommodate itself successfully to the reception of Greek science, to a language previously used almost exclusively for religious and liturgical purposes.[16] Instead of inventing new words or borrowing them from another language, Ibn Ezra used Biblical words as scientific terms, thus contributing to the transformation of Hebrew into a scientific language.

Maimonides and the art of medicine

In the field of medicine, the most important figure in the Middle Ages is Moshe ben Maimon known as Maimonides. Born in Cordoba in 1138, he left the country when very young and travelled through al-Andalus, Morocco, where he lived for some years, and North Africa. He finally settled in Egypt, where he practised medicine and became the physician of the sultan's family. Maimonides' medical works, written in Arabic at the request of high dignitaries, sultans, and viziers, are part of Arab medicine, which is a continuation of Greek medicine, and especially that of Galen and Hippocrates.[17] The general ideas of Arab medicine, such as the theory of the four humours or fluids are present in Maimonides' medical treatises. According to this theory, blood, phlegm, yellow bile and black bile are the basic constituents of the body, and imbalances among these humours generate diseases.

Maimonides' *Treatise on the Regimen of Health* was dedicated to the Sultan of Egypt, Al-Afdal, the eldest son of the great Saladito. Al-Afdal sent a messenger to Maimonides, asking him to write a book to cure him from his illnesses, including bad digestion and constipation. The messenger also mentioned that his master occasionally developed depression, evil thoughts, and fear of death.

As was customary in medieval medicine, Maimonides recommended an appropriate food regimen to cure the sultan of his problems. If this did not work, some medicines and drugs were recommended. Surgery was the last step. It had a very bad reputation and was considered the remedy of bad doctors. In the *Treatise on haemorrhoids*, dedicated to a high dignitary whose name is unknown, Maimonides recommends certain foods to cure this illness, but not medicines, and he specifically rejects the use of surgery.

Maimonides' main idea in his *Treatise on the Regimen of Health* may be summarized in the motto 'a healthy mind in a healthy body.' This is one of the most significant treatises on the psychosomatic aspect of medicine. Maimonides posits that the physical well-being of a person is dependent on his mental well-being. He also emphasizes preventive medicine and mental hygiene as of fundamental importance in the maintenance of health, and stresses the importance of knowing the specific characteristics of the patient in order to apply the correct treatment. He recommends: treat the patient, not the illness. He recommends a nap after lunch, foods that contribute to the increase of the good humours, and avoiding foods that increase the bad humours.

Maimonides' other medical works are: *Treatise on Asthma*, *Treatise on Poisons*, *Commentary on the Aphorisms of Hippocrates*, *The Art of Cure*, *The Medical Aphorisms of Moses Maimonides*, and a *Treatise on Cohabitation*. This last was written at the request of Al-Malik al Mustaffar ben Ajjub, Sultan of Hamat, Syria, and nephew of Saladin the Great of Egypt. In his request, the sultan informed Maimonides that he had a big harem and was unable to satisfy sexually the multitude of his young maidens. He asked Maimonides to give him advice on how to increase his sexual potential and coital activities. The book mainly contains recipes for foods and drugs that have an aphrodisiac effect. Surprisingly, Maimonides recommends wine, in spite of addressing a Muslim. He also advocates moderation in sexual activity.

Maimonides used his knowledge of foods and their medical applications to justify the Jewish religious laws and precepts concerning food. In his *Mishneh Torah*, which is a rational explanation of the Jewish laws, he frequently makes use of his medical knowledge to justify the divine precepts. For example, he affirms that Jewish religious precepts are in accordance with the rules of hygiene, and says that 'by keeping the body in health and vigour one walks in the ways of God.' He used the medieval astronomical principles and laws in order to justify the religious precepts concerning the calendar, but he rejects the use of astrology

for any purpose. In a letter to the rabbis of the south of France, he affirms that belief in the determination of acts of human beings by the stars is completely absurd. In his medical treatises he also chides those linking astrology and medicine, considering them charlatans, and bad physicians, whose advice should not be followed. Maimonides also represents the culmination of the Judeo-Arabic philosophical tradition. His masterwork, *Guide of the Perplexed*, written in Arabic, traditionally has been considered as the epitome of Aristotelianism in Jewish philosophy. He also adopted several philosophical ideas of Muslim theologians and philosophers, such as al-Farabi or Ibn Bajja, among others. The cardinal point of Maimonides' negative theology – that is, that God should not be regarded as having any positive attributes pertaining to His essence, and that He should only be described by using negative attributes – was taken from Avicenna's philosophic system.

Soon after Maimonides wrote his works, they were translated into Hebrew by the Jewish Ibn Tibbon family of translators in the south of France. These translations contributed to the expansion of medicine and philosophy in the Jewish communities of Europe and were also translated into Latin, thus influencing Christian thinkers such as Thomas Aquinas.

The School of Translators of Toledo

In Christian Spain, the process of translation continued in the 12th and 13th centuries in the so-called 'School of Translators of Toledo.' Under the patronage of archbishop Raimundo, Jewish scholars were invited to participate in the process of transmission of science. Iohannes Avendeut Hispanus collaborated with the Christian Dominicus Gundissalinus in the translation of several philosophical works by Aristotle, Ibn Gabirol's *Fons Vitae*, and al-Ghazali's books on logic and philosophy, which became very influential among scholastic Christian theologians.

In the 13th century, the 'School' received stimulation from Alfonso X, the king of Castile, and engaged in a second wave of translations. Works on astronomical and astrological subjects, such as Abenragel's treatise on judicial astrology *Libro conplido en los iudizios de las estrellas*, were translated from Arabic into Castilian and Latin. Jewish scholars such as Judah ben Moses and Isaac Ibn Said, together with Christian and Muslim partners, contributed to the preparation of the *Tablas alfonsies* (*Alphonsine Tables*), a set of tables with the positions of stars and planets in heaven as observed in Toledo in the year 1252, accompanied by much astronomical information. They were translated into Latin by John of Saxony in the 14th century. The *Alphonsine Tables* served as the standard guide to the practice of mathematical astronomy until the 16th century and were said to have been used by Nicolaus Copernicus. Judah ben Moses and

Isaac Ibn Said also participated in the preparation of the *Libro del saber de astronomía* (*The Book of Astronomical Knowledge*), a compilation of treatises on the construction of astronomical instruments, clocks and astrolabes.[18]

The court of Peter IV in Aragon

In the 14th century, Pedro IV of Aragon aspired to be a cultured and enlightened monarch. He wanted to emulate the cultural atmosphere of Castile under Alfonso X, and promoted the study of sciences, mostly astronomy and medicine, and also the occult sciences, in his kingdom. Two important Jewish scientists, Cresques Abraham and his son Jafuda Cresques, produced in 1375 an atlas of the world as it was then known, that is, from Spain to India. The work includes illustrations of the kings of the most important countries, and texts about legends, traditions, anecdotes, and religious ideas. Along the Mediterranean shoreline the authors listed the names of ports and cities, so that the map could be used for navigational purposes. A flag indicated whether a city was Christian or Muslim. This map combined scientific and religious ideas. The Cresques placed the figure of the Antichrist in China, and drew the prophet Isaiah announcing the coming of the Messiah. Other legends taken from the Bible and other sources, such as the book of travels of Marco Polo, were also included. Special attention was given to the holy places of the three religions: Jerusalem, Mount Sinai, Mecca and Medina. In Mecca they drew a Muslim praying. They did not especially distinguish Rome or Santiago de Compostela, although these were the two most important cities for medieval Christianity, and even though the map was commanded by a Christian king. In spite of the informative value of the atlas, it seems not to have been used for practical purposes. Cresques Abraham and Jafuda Cresques were not cartographists *strictu sensu*, but just good artists and draughtsmen.

The end of the Jewish transmission of science

In the 15th century, the most important figure in Jewish science is Abraham Zacuto. He was born in Salamanca in 1452. In this city he too specialized in astronomy, astrology and mathematics. His main work on astronomy was *Hibbur ha-gadol* (*The Great Composition*), written in Hebrew. This was soon translated into Castilian and Latin as *Almanach Perpetuum* (*Perpetual Almanach*). It contains a new series of astronomical tables, an improvement on the *Alphonsine Tables*, which were used by sailors and navigators to determine the position of the Sun, and thus accurately orientate themselves. They were also used to calculate solar and lunar eclipses.[19] Zacuto's main contribution to medieval science was his adaptation of astronomical theories and instruments to the necessities of navigation. As such, his input was crucial to the Spanish and Portuguese discoveries of the 16th century. It has been said that Zacuto advised

Vasco da Gama on his voyage to India in 1496. Zacuto strongly influenced subsequent astronomers. The *Almanach Perpetuum* went through several editions in Latin and Castilian in the 16th century. There were also at least two translations into Arabic. Zacuto's influence on Jewish scholars was most notable in the Eastern Islamic world.

After the expulsion of the Jews in 1492, Zacuto emigrated to Portugal where he served the Kings John II and Manuel I as a court astronomer. In 1497, with the expulsion of the Jews from Portugal, he left for North Africa and finally settled in Tunis. He spent the rest of his life teaching mathematics and astronomy, and his last work on astrology can be considered as the final chapter of the history of the Jewish contribution to science in the Middle Ages.

In his book *Judgments of the Astrologer* he wrote:

> In the year 1524 there will be a conjunction of the planets unlike any that came before it. It indicates that there will be great woes in Christian countries to the west, and that the sea will rise and some of their lands will be flooded. Happy is he who waits and reaches that year in repentance, upright in heart, and in good deeds. And in that year will be redemption and salvation for Israel… and the coming of the Messiah, son of David, may God be blessed for the sake of His name, may He help us and support us and maintain us with His righteous right hand, and may He inscribe us for a good life with all that is written for life, to look upon the goodness of God in the land of life. Amen, may it be His will.

The ultimate goal of astronomy, astrology, and mathematics was to provide the necessary knowledge for the calculation of the date of the coming of the Messiah, and also to bring consolation, comfort, and hope to all the Jews who felt desperate and disillusioned by the terrible experiences of the expulsion. If the history of the Jewish people concludes with the coming of the Messiah from a theological point of view, the final chapter of the history of the Jewish contribution to science in medieval Iberia also concludes with the astrological calculations to predict scientifically the coming of the Messiah.

References and notes

1. B. R. Goldstein, (ed.) 1967) *Ibn al-Muthanna's Commentary on the Astronomical Tables of al-Khwarizmi* (New Haven, London: Yale University Press), pp. 4, 147–148.
2. J. Pelaez del Rosal (1988) Hasdai Ibn Shaprut in the Court of Abd-ar-Rahman III. In: J. Pelaez del Rosal (ed.) *The Jews in Cordoba (X-XII Centuries)* (Cordoba: El almendro), pp. 61–77: 68.
3. C. E. Dubler (1953) *La 'Materia Médica' de Dioscórides: transmisión medieval y renacentista* (Barcelona: Emporium), p. 51.
4. D. J. Wasserstein (1997) The Muslims and the Golden Age of the Jews in al-Andalus. *Israel Oriental Studies*, **17**, 179–196: 189.

5. D. J. Wasserstein (1997) The Muslims and the Golden Age of the Jews in al-Andalus. *Israel Oriental Studies*, **17**, 190.
6. S. Sela (2005) Abraham Bar Hiyya's astrological work and thought. *Jewish Studies Quarterly*, **12**, 128–158.
7. J. M. Millas Vallicrosa (1942) *Las traducciones orientales en los manuscritos de la Biblioteca Catedral de Toledo* (Madrid: CSIC), p. 153.
8. J. M. Millas Vallicrosa (1943) La aportación astronómica de Pedro Alfonso. *Sefarad*, **3**, 65–105.
9. Abraham ibn Ezra (1995) *The Secret of the Torah*. Translated and Annotated by H. Norman Strickman (Northvale-London: Jason Aronson), pp. 8, 21 and 22.
10. T. Levy (2000) Abraham ibn Ezra et les mathematiques: Remarques bibliographiques et historiques. In: P. J. Tomson (ed.) *Abraham ibn Ezra, savant universel* (Bruxelles: Institutum Iudaicum), pp. 60–75.
11. S. Sela (2001) Abraham ibn Ezra's scientific corpus: basic constituents and general characterization. *Arabic Sciences and Philosophy*, **11**, 91–149.
12. A. Allard (1991) The Arabic origins and development of Latin algorisms in the twelfth century. *Arabic Sciences and Philosophy*, **1**, 233–283.
13. U. Simon (2000) Abraham ibn Ezra. In: M. Saebo (ed.) *Hebrew Bible/Old Testament: The History of Its Interpretation. Vol. I, Part 2: The Middle Ages* (Göttingen: Vandenhoeck and Ruprecht), pp. 377–387: 379.
14. M. Gomez-Aranda (2006) The meaning of Qohelet according to Ibn Ezra's scientific explanations. *Aleph*, **6**, 339–370.
15. Abraham ibn Ezra (1996) *Commentary on the Pentateuch: Exodus (Shemot)*. Translated and Annotated by H. N. Strickman and A. M. Silver (New York: Menorah Publishing Company), pp. 433–434.
16. S. Sela (2003) *Abraham ibn Ezra and the Rise of Medieval Hebrew Science* (Leiden-Boston: E.J. Brill), p. 95.
17. H. A. Davidson (2005) *Moses Maimonides: The Man and His Works* (Oxford: Oxford University Press), pp. 429–483.
18. D. Romano (1992) The Jews' contribution to medicine, science and general learning. In: H. Beinart (ed.) *Moreshet Sepharad: The Sephardi Legacy* (Jerusalem: The Magnes Press, The Hebrew University), vol. 1, pp. 240–260.
19. J. Chabás and B. R. Goldstein (2000) *Astronomy in the Iberian Peninsula: Abraham Zacut and the Transition from Manuscript to Print* (Philadelphia: American Philosophical Society).

About the Author

Mariano Gomez-Aranda is a Scientist at the Spanish High Council for Scientific Research (CSIC). He is a member of the Editorial Board of the journal *Sefarad*. He is also a Lecturer at New York University in Madrid, teaching on Jewish culture in Medieval Spain. He has published several books and articles on the role of Spanish Jews in the history of medieval exegesis, science and philosophy.