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Inventions and Scientific Discoveries Of Andalusian Scholars

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Abstract: This article discusses the inventions and scientific discoveries made by Andalusian scholars in various fields of science. The scientific environment in which these scholars flourished, the works they authored, the influence of these works on subsequent generations of scientists, and the contemporary significance of the Andalusian scholars' scientific heritage are analyzed. Special attention is also given to female Andalusian scholars.

Keywords: Invention, Scientific Discovery, Mechanics, Astronomy, Mathematics, Surgery, Cartography, Medicine, Botany.

Introduction

It is widely known that during the Middle Ages, the Muslim world achieved remarkable progress in the scientific and cultural spheres. Among the scholars who contributed to this scientific advancement were those from Andalusia (present-day Spain and Portugal), where Muslims ruled from 711 to 1492. The inventions and scientific discoveries made by these scholars remain significant even today. Andalusian scientists have left their mark in history across various fields of science, including mechanics, astronomy, mathematics, surgery, cartography, medicine, and botany.

Methodology

One of the first mechanical pioneers of Andalusia was Abul Qasim Abbas ibn Firnas (d. 887), who was born in the village of Takuranna in the Ronda province of Andalusia. Abbas ibn Firnas grew up and studied in Cordoba, the capital of Andalusia, and despite his youth, gained fame in the fields of philosophy, chemistry, astronomy, and literature. Curious and inquisitive, Abbas made many inventions. One of them was a clock called "miqata" made for Emir Muhammad I. Abbas held the title of "Hakimu-l-Andalus" in his

time. It is also known that he was interested in music. It is also reported that some envious people of his time accused him of sorcery and heresy. Until now, none of his works have survived, except for several poetic examples found in Ibn Hayyan's work "al-Muqtabis." One of the achievements that etched the name of Abbas ibn Firnas in history was his creation of a flying device and his attempt to fly with it. In 852, he jumped from the roof of a mosque wearing a wide, sleeveless garment with wooden sticks attached, which fluttered freely. Ibn Firnas's dream of flying freely like a bird was not fulfilled, but the wide garment that slowed his descent could be considered the first parachute. Later, he invented an early version of a hang glider and attempted to fly again. At the end of his flight, which lasted several minutes, he fell to the ground. Despite his failures, his flights served as a source of inspiration for the creation of modern air transport. In honor of this Andalusian scientist, one of the craters on the Moon is named after him, as well as an airport in Baghdad and one of the bridges over the Guadalquivir River in Cordoba are named after Ibn Firnas. In honor of this Andalusian scientist, one of the craters on the Moon is named after him, as well as an airport in Baghdad and one of the bridges of the Guadalquivir River in Cordoba are named after Ibn Firnas.

Abul Qasim Khalaf ibn Abbas Zahrawi, known in the West as Abulcasis or Zahravius, was born in 936 CE in Madinat al-Zahra, 6 km northwest of Cordoba. Zahrawi traveled little during his life and spent most of his time in his homeland as a practicing physician, pharmacist, and surgeon . He worked as a court physician during the reign of Al-Hakam II. Around the year 1000, he wrote his famous work "Kitab al-Tasrif". This was the result of fifty years of teaching, research, practice, and experience in the field of medicine. This thirty-volume medical encyclopedia covers various aspects of medical knowledge. In addition to sections on medicine and surgery, it also included chapters on obstetrics, pharmacology, therapy, dietetics, psychotherapy, weights and measures, and medical chemistry. "Al-Tasrif" dedicates three chapters to surgery. Zahrawi invented instruments for internal examination of the ear. He created a device that allows for the removal or insertion of objects in the throat. He described temporary arterial compression and division to alleviate certain types of headaches. He performed ligature application on bleeding vessels and internal suturing using catgut. He was the first to use sutures extensively in Europe, centuries before the famous French military surgeon Ambroise Paré (1510-1590). He performed gallbladder treatments and invented devices for removing bladder stones and examining the urinary tract. Zahrawi was the first person to describe ectopic pregnancy. He invented numerous dental instruments and artificial teeth made from animal bones. Zahrawi is considered the father of operative surgery. He presented more than 200 surgical instruments in his work, which was an astonishing number by all standards. His works became highly valued in the West, especially after being translated by Gerard of Cremona, Rogerius Frugardi, Roland of Parma, and others. His teachings on surgery were considered the most advanced until the 13th century. "Al-Tasrif" remained an integral part of the medical curriculum in European countries for many centuries. The work "At-Tasrif" has been an integral part of the medical curriculum in European countries for many centuries.

Muradi was one of the scientists who lived and worked in Andalusia in the 11th century. The only surviving, albeit defective, copy of his work "Kitab al-asrar fi nata'ij al-afkar" is preserved in a library in Florence. The work contains important information about

clocks and other mechanical devices. Muradi lived during the same period as the famous astronomer Al-Zarqali and collaborated with him in creating an astrolabe. The research of both scientists is included in the work “The Libros del Saber de Astronomia” by King Alfonso X of Castile. Muradi's work was translated into English in 2008 by the Italian company “Leonardo3” and published along with three-dimensional illustrations. This work is considered the most important treatise on mechanical engineering written in Andalusia. The mechanical systems described in it were later implemented in both Andalusian and European countries. The work depicts mechanical toys, water-powered clocks, war machines, devices operating on water's lifting force, and sundials.

Abulqasim Maslama ibn Ahmad Majriti was born in 950 in Madrid, the capital of modern Spain, which at that time was called Majrit. As a young man, he went to Cordoba and studied there. He became the most famous scientist during the era of Caliph Hakam II and continued as the chief astronomer of the palace during subsequent caliphs' reigns. He conducted astronomical observations in Cordoba in 979 and noted that he observed Regulus, the brightest star in the Leo constellation. He was the most prominent scientist in the fields of mathematics and astronomy of his time. Known as the “Andalusian Euclid,” Majriti founded a school of arithmetic and astronomy and laid the foundation for systematic scientific research. Working with his students on Khwarazmi's work "Zij," he reconstructed the zij according to the Cordoba meridian and the lunar calendar, and made important additions to the astronomical tables in the work. This version of the work was translated into Latin by Adelard of Bath in the 12th century. He also studied al-Battani's “Zij,” made additions to it, and introduced the work to Europe. He also studied Ptolemy’s work “Planisphaerium” and made important additions to it. According to Said al-Andalusi, he was the best mathematician and astronomer of Andalusia in his time. He also wrote about the economy and taxation of Andalusia .

Maslama al-Majriti, one of the most knowledgeable people of his time, left behind many students. One of them was his daughter, Fatima al-Majritiyya, considered one of the Andalusian scholars. The calendar “Women astronomers who made history,” published in 2009, writes about her as follows: She wrote many works known as “Tashihat Fatima.” Together with her father, she edited and corrected the astronomical tables of al-Khwarizmi. They also worked on calendars, calculations of the correct positions of the Sun, the Moon and planets, sine and tangent tables, spherical astronomy, astrological tables, solar and lunar eclipses, and lunar visibility issues . She holds a unique place in the scientific development of Andalusia. The Spanish orientalist Manuel Moren said: “She is undoubtedly one of the most famous women of Andalusia who contributed to the creation of history.”

Result and Discussion

Another Andalusian scholar who inscribed her name in golden letters on the Islamic millennium was Lubna of Cordoba. She lived in the capital Cordoba during the period of the Andalusian Umayyads in the 10th century. Al-Hakam II (961-976) appointed her as the head of the Cordoba Public Library. In addition to librarianship, the scholar also engaged

in translation work. She translated the books of mathematicians such as Euclid and Archimedes. Even more noteworthy is that Lubna did not limit herself to translations alone but added her own thoughts on mathematics to them. It is noted that Lubna was one of the geniuses of mathematics in her time.

Abu Ishaq Ibrahim Zarkali (1029-1087), known in the West as "Arzachel," was born in Toledo. He was exceptionally talented in geometry and astronomy. His extensive knowledge and experience made him the foremost astronomer of his time. Zarkali was also an inventor, and his works contributed to Toledo becoming the intellectual center of Andalusia. In 1085, Toledo was conquered by King Alfonso VI of Castile. Consequently, Zarkali was forced to flee the city. His scientific works influenced subsequent scholars such as Ibn Bajja, Ibn Tufail, Ibn Rushd, Ibn Kammad, Ibn Hayim al-Ishbili, and Nur ad-Din al-Bitruji. In the 12th century, Gerard of Cremona translated Zarkali's works into Latin. He referred to Zarkali as an astronomer and magician. In 1530, the German scholar Jakob Ziegler wrote a commentary on one of Zarkali's works. Nicolaus Copernicus quoted the works of Zarkali and al-Battani in his "De revolutionibus orbium coelestium." Zarkali wrote two treatises on constructing instruments for calculating planetary positions using diagrams from the Ptolemaic model. These works were translated into Spanish in the 13th century by order of King Alfonso X. He also invented a sophisticated astrolabe called "as-Safiha az-zarqaliyya" (Zarkali's plate), which became known in Europe as "Saphaea."

Abu Muhammad Jabir ibn Aflah, a mathematician and astronomer from Seville, lived and worked in the 12th century. The work that brought him worldwide recognition was "Islah al-Majisti," in which he corrected errors in Ptolemy's "Almagest." Although Europeans claimed that he slandered Ptolemy in this work, his treatise was translated into Latin by Gerard of Cremona, and into Hebrew in 1274 by Moses ibn Tibbon and later by Jacob ibn Mahir. Copernicus used Jabir's spherical trigonometry without citing the source.

Another renowned astronomer who lived in the 12th century was Abu Ishaq Nuruddin al-Bitruji. His name was Latinized as "Alpetragius." At the recommendation of his teacher Ibn Tufail, he undertook the task of correcting errors in Ptolemaic astronomy. In this process, he first familiarized himself closely with Jabir ibn Aflah's work "Islah al-Majisti" and subsequently wrote his own treatise "Kitab al-Hay'a.' The book was translated into Latin by Michael Scotus in 1217, and into Hebrew by Moses ibn Tibbon in 1259. This work gained popularity in Europe during the 13th-16th centuries and was accepted in scientific circles as a worthy alternative to Ptolemy's "Almagest."

Moses ibn Maimon (1135-1204) is considered the most famous Andalusian Jewish scholar in history. In his time, he was known as a rabbi, Talmudic scholar, and physician. The Jewish community recognized him with the saying, "From Moses to Moses, there was no one like Moses." Born in the intellectual city of Cordoba, Ibn Maimon received excellent rabbinical education under the guidance of his father, who was a judge of the Sharia court. Later, Maimon's family moved to Fez, where he memorized the Holy Quran and studied Islamic jurisprudence. Subsequently, he went with his family to Jerusalem. After his father stayed in Jerusalem, Maimon moved to Egypt. In Egypt, as his financial situation

deteriorated, he began to practice medicine. He first became the personal physician of the vizier Al-Qadi al-Fadil, and later of Saladin and his son. In Egypt, alongside religious studies, he conducted scientific research in mathematics, astronomy, and philosophy, and trained many students. In 1172, Maimon was elected as the leader of the Jewish community. Contributing to the development of Jewish theology, he established new and well-founded regulations in matters of faith and worship. Due to these services, he became known as the "Second Moses" of the Jewish community. More than 20 of his works written in Arabic have been translated into various languages worldwide. Maimon studied Al-Ghazali extensively in Islamic sciences and approved of his views. He attempted to harmonize Aristotelian philosophy with Judaism. Ibn Maimon's most important work is the 14-volume book "Mishneh Torah," which is considered a codification of Jewish law. Written as a commentary on the Talmud, the Jewish book of religious law, it is the author's only work written in Hebrew. In writing it, he used not only the Babylonian Talmud but also the Jerusalem Talmud and other Jewish sources. Roger Garaudy writes: "Jewish doctrine is based on three sources: the Torah, which established the law, the Talmud, which is its commentary, and the philosophy of Ibn Maimon."

Abu Bakr Muhammad ibn Yahya ibn as-Saigh at-Tujibi ibn Bajjah was an Andalusian polymath and the author of works on astronomy, physics, music, philosophy, medicine, botany, and poetry. He was born in Zaragoza in 1085 and died in Fez in 1138. In the field of botany, he wrote "Kitab an-Nabat" (The Book of Plants) on determining the sex of plants. He was a renowned scholar of his time in medicine, mathematics, and astronomy. His contribution to Islamic philosophy is characterized by his concept of the phenomenology of the soul. Although many of his works have not survived to the present day, his theories on astronomy and physics were preserved in the works of Maimonides (Moses ibn Maimon) and Ibn Rushd, and later influenced the scientific endeavors of Renaissance astronomers and physicists, including Galileo Galilei . In 2009, the International Astronomical Union named a crater located 199 km from the Moon's south pole after Ibn Bajjah.

It is difficult to imagine the development of geography and cartography in Andalusia without the legacy of Muhammad Sharif al-Idrisi (1100-1165). Al-Idrisi was born in 1100 in Ceuta, studied in Córdoba, and served at the court of King Roger II in Palermo for a period. Having traveled to Anatolia at the age of 16, al-Idrisi subsequently journeyed through European countries such as Portugal, France, and Hungary. In 1154, after living in the court of King Roger II of Sicily for 18 years, al-Idrisi created a map for the king called "Tabula Rogeriana." Although the map was in Arabic and not free from errors, it remained in use for the next three centuries. Even the world maps used by explorers such as Christopher Columbus and Vasco da Gama were based on his cartography. Al-Idrisi also influenced the work of geographers from the Islamic world, such as Ibn Battuta, Ibn Khaldun, and Piri Reis. Moreover, many other maps created by al-Idrisi have survived to this day. He also crafted a silver globe for King Roger II, measuring two meters in diameter and weighing 400 kg. He placed seven continents on the globe with great precision, depicting trade routes, lakes, rivers, major cities, plains, and mountains. His work "Nuzhat al-mushtaq" is considered a

valuable source on medieval cartography. This work is one of the most studied sources in the field of cartography. “Nuzhat al-mushtaq” is a comprehensive scientific treatise on the general and systematic geography of the Earth. It is also notable for providing the most accurate information about Europe available at that time.

Another Andalusian scholar, Abdullah ibn Baytar (1197–1248), was a renowned pharmacologist, botanist, and physician. His greatest contribution to science was the addition of nearly 400 medicinal plants he discovered to the list of known remedies of medieval physicians, systematically organizing them. In 1219, Ibn Baytar embarked on a journey from Malaga to discover new plant species, traveling from North Africa to Asia Minor. By 1224, he had become the chief physician at the court of the Ayyubid ruler Sultan al-Kamil, which opened up extensive opportunities for his research. Among his major works in his field are “Kitab al-Jami‘ li-Mufradat al-Adwiya wa-al-Aghdhiya” and “Kitab al-Mughni fi al-Adwiya al-Mufrada.”

Conclusion

In general, Andalusian scholars made groundbreaking discoveries and inventions in nearly every field of medieval science. The 1903 Nobel Prize in Physics winner, the French physician Pierre Curie, says: “We have 30 books left behind from Muslim Andalusia , so that we could split the atom if half of one million burned books a could survive ,we would already travel between the galaxy space.” This statement underscores the immense value of the scientific legacy of medieval Andalusian scholars.

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