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How Islam Won, and Lost, the Lead in Science

By DENNIS OVERBYE

Nasir al-Din al-Tusi was still a young man when the Assassins made him an offer he couldn't refuse.

His hometown had been devastated by Mongol armies, and so, early in the 13th century, al-Tusi, a promising astronomer and philosopher, came to dwell in the legendary fortress city of Alamut in the mountains of northern Persia.

He lived among a heretical and secretive sect of Shiite Muslims, whose members practiced political murder as a tactic and were dubbed hashishinn, legend has it, because of their use of hashish.

Although al-Tusi later said he had been held in Alamut against his will, the library there was renowned for its excellence, and al-Tusi thrived there, publishing works on astronomy, ethics, mathematics and philosophy that marked him as one of the great intellectuals of his age.

But when the armies of Halagu, the grandson of Genghis Khan, massed outside the city in 1256, al-Tusi had little trouble deciding where his loyalties lay. He joined Halagu and accompanied him to Baghdad, which fell in 1258. The grateful Halagu built him an observatory at Maragha, in what is now northwestern Iran.

Al-Tusi's deftness and ideological flexibility in pursuit of the resources to do science paid off. The road to modern astronomy, scholars say, leads through the work that he and his followers performed at Maragha and Alamut in the 13th and 14th centuries. It is a road that winds from Athens to Alexandria, Baghdad, Damascus and Córdoba, through the palaces of caliphs and the basement laboratories of alchemists, and it was traveled not just by astronomy but by all science.

Commanded by the Koran to seek knowledge and read nature for signs of the Creator, and inspired by a treasure trove of ancient Greek learning, Muslims created a society that in the Middle Ages was the scientific center of the world. The Arabic language was synonymous with learning and science for 500 hundred years, a golden age that can count among its credits the precursors to modern universities, algebra, the names of the stars and even the notion of science as an empirical inquiry.

"Nothing in Europe could hold a candle to what was going on in the Islamic world until about 1600," said Dr. Jamil Ragep, a professor of the history of science at the University of Oklahoma.

It was the infusion of this knowledge into Western Europe, historians say, that fueled the Renaissance and the scientific revolution.

"Civilizations don't just clash," said Dr. Abdelhamid Sabra, a retired professor of the history of Arabic science who taught at Harvard. "They can learn from each other. Islam is a good example of that." The intellectual meeting of Arabia and Greece was one of the greatest events in history,

he said. "Its scale and consequences are enormous, not just for Islam but for Europe and the world."

But historians say they still know very little about this golden age. Few of the major scientific works from that era have been translated from Arabic, and thousands of manuscripts have never even been read by modern scholars. Dr. Sabra characterizes the history of Islamic science as a field that "hasn't even begun yet."

Islam's rich intellectual history, scholars are at pains and seem saddened and embarrassed to point out, belies the image cast by recent world events. Traditionally, Islam has encouraged science and learning. "There is no conflict between Islam and science," said Dr. Osman Bakar of the Center for Muslim-Christian Understanding at Georgetown.

"Knowledge is part of the creed," added Dr. Farouk El-Baz, a geologist at Boston University, who was science adviser to President Anwar el- Sadat of Egypt. "When you know more, you see more evidence of God."

So the notion that modern Islamic science is now considered "abysmal," as Abdus Salam, the first Muslim to win a Nobel Prize in Physics, once put it, haunts Eastern scholars. "Muslims have a kind of nostalgia for the past, when they could contend that they were the dominant cultivators of science," Dr. Bakar said. The relation between science and religion has generated much debate in the Islamic world, he and other scholars said. Some scientists and historians call for an "Islamic science" informed by spiritual values they say Western science ignores, but others argue that a religious conservatism in the East has dampened the skeptical spirit necessary for good science.

The Golden Age

When Muhammad's armies swept out from the Arabian peninsula in the seventh and eighth centuries, annexing territory from Spain to Persia, they also annexed the works of Plato, Aristotle, Democritus, Pythagoras, Archimedes, Hippocrates and other Greek thinkers.

Hellenistic culture had been spread eastward by the armies of Alexander the Great and by religious minorities, including various Christian sects, according to Dr. David Lindberg, a medieval science historian at the University of Wisconsin.

The largely illiterate Muslim conquerors turned to the local intelligentsia to help them govern, Dr. Lindberg said. In the process, he said, they absorbed Greek learning that had yet to be transmitted to the West in a serious way, or even translated into Latin. "The West had a thin version of Greek knowledge," Dr. Lindberg said. "The East had it all."

In ninth-century Baghdad the Caliph Abu al-Abbas al-Mamun set up an institute, the House of Wisdom, to translate manuscripts. Among the first works rendered into Arabic was the Alexandrian astronomer Ptolemy's "Great Work," which described a universe in which the Sun, Moon, planets and stars revolved around Earth; Al-Magest, as the work was known to Arabic scholars, became the basis for cosmology for the next 500 years.

Jews, Christians and Muslims all participated in this flowering of science, art, medicine and philosophy, which endured for at least 500 years and spread from Spain to Persia. Its height,

historians say, was in the 10th and 11th centuries when three great thinkers strode the East: Abu Ali al- Hasan ibn al-Haytham, also known as Alhazen; Abu Rayham Muhammad al-Biruni; and Abu Ali al-Hussein Ibn Sina, also known as Avicenna.

Al-Haytham, born in Iraq in 965, experimented with light and vision, laying the foundation for modern optics and for the notion that science should be based on experiment as well as on philosophical arguments. "He ranks with Archimedes, Kepler and Newton as a great mathematical scientist," said Dr. Lindberg.

The mathematician, astronomer and geographer al-Biruni, born in what is now part of Uzbekistan in 973, wrote some 146 works totaling 13,000 pages, including a vast sociological and geographical study of India.

Ibn Sina was a physician and philosopher born near Bukhara (now in Uzbekistan) in 981. He compiled a million-word medical encyclopedia, the *Canons of Medicine*, that was used as a textbook in parts of the West until the 17th century.

Scholars say science found such favor in medieval Islam for several reasons. Part of the allure was mystical; it was another way to experience the unity of creation that was the central message of Islam.

"Anyone who studies anatomy will increase his faith in the omnipotence and oneness of God the Almighty," goes a saying often attributed to Abul-Walid Muhammad Ibn Rushd, also known as Averroes, a 13th-century anatomist and philosopher.

Knocking on Heaven's Door

Another reason is that Islam is one of the few religions in human history in which scientific procedures are necessary for religious ritual, Dr. David King, a historian of science at Johann Wolfgang Goethe University in Frankfurt, pointed out in his book "Astronomy in the Service of Islam," published in 1993. Arabs had always been knowledgeable about the stars and used them to navigate the desert, but Islam raised the stakes for astronomy.

The requirement that Muslims face in the direction of Mecca when they pray, for example, required knowledge of the size and shape of the Earth. The best astronomical minds of the Muslim world tackled the job of producing tables or diagrams by which the qibla, or sacred directions, could be found from any point in the Islamic world. Their efforts rose to a precision far beyond the needs of the peasants who would use them, noted Dr. King.

Astronomers at the Samarkand observatory, which was founded about 1420 by the ruler Ulugh Beg, measured star positions to a fraction of a degree, said Dr. El-Baz.

Islamic astronomy reached its zenith, at least from the Western perspective, in the 13th and 14th centuries, when al-Tusi and his successors pushed against the limits of the Ptolemaic world view that had ruled for a millennium.

According to the philosophers, celestial bodies were supposed to move in circles at uniform speeds. But the beauty of Ptolemy's attempt to explain the very ununiform motions of planets

and the Sun as seen from Earth was marred by corrections like orbits within orbits, known as epicycles, and geometrical modifications.

Al-Tusi found a way to restore most of the symmetry to Ptolemy's model by adding pairs of cleverly designed epicycles to each orbit. Following in al-Tusi's footsteps, the 14th-century astronomer Ala al-Din Abul-Hasan ibn al-Shatir had managed to go further and construct a completely symmetrical model.

Copernicus, who overturned the Ptolemaic universe in 1530 by proposing that the planets revolved around the Sun, expressed ideas similar to the Muslim astronomers in his early writings. This has led some historians to suggest that there is a previously unknown link between Copernicus and the Islamic astronomers, even though neither ibn al-Shatir's nor al-Tusi's work is known to have ever been translated into Latin, and therefore was presumably unknown in the West.

Dr. Owen Gingerich, an astronomer and historian of astronomy at Harvard, said he believed that Copernicus could have developed the ideas independently, but wrote in *Scientific American* that the whole idea of criticizing Ptolemy and reforming his model was part of "the climate of opinion inherited by the Latin West from Islam."

The Decline of the East

Despite their awareness of Ptolemy's flaws, Islamic astronomers were a long ways from throwing out his model: dismissing it would have required a philosophical as well as cosmological revolution. "In some ways it was beginning to happen," said Dr. Ragep of the University of Oklahoma. But the East had no need of heliocentric models of the universe, said Dr. King of Frankfurt. All motion being relative, he said, it was irrelevant for the purposes of Muslim rituals whether the sun went around the Earth or vice versa.

From the 10th to the 13th century Europeans, especially in Spain, were translating Arabic works into Hebrew and Latin "as fast as they could," said Dr. King. The result was a rebirth of learning that ultimately transformed Western civilization.

Why didn't Eastern science go forward as well? "Nobody has answered that question satisfactorily," said Dr. Sabra of Harvard. Pressed, historians offer up a constellation of reasons. Among other things, the Islamic empire began to be whittled away in the 13th century by Crusaders from the West and Mongols from the East.

Christians reconquered Spain and its magnificent libraries in Córdoba and Toledo, full of Arab learning. As a result, Islamic centers of learning began to lose touch with one another and with the West, leading to a gradual erosion in two of the main pillars of science — communication and financial support.

In the West, science was able to pay for itself in new technology like the steam engine and to attract financing from industry, but in the East it remained dependent on the patronage and curiosity of sultans and caliphs. Further, the Ottomans, who took over the Arabic lands in the 16th century, were builders and conquerors, not thinkers, said Dr. El-Baz of Boston University, and support waned. "You cannot expect the science to be excellent while the society is not," he said.

Others argue, however, that Islamic science seems to decline only when viewed through Western, secular eyes. "It's possible to live without an industrial revolution if you have enough camels and food," Dr. King said.

"Why did Muslim science decline?" he said. "That's a very Western question. It flourished for a thousand years — no civilization on Earth has flourished that long in that way."

Islamic Science Wars

Humiliating encounters with Western colonial powers in the 19th century produced a hunger for Western science and technology, or at least the economic and military power they could produce, scholars say. Reformers bent on modernizing Eastern educational systems to include Western science could argue that Muslims would only be reclaiming their own, since the West had inherited science from the Islamic world to begin with.

In some ways these efforts have been very successful. "In particular countries the science syllabus is quite modern," said Dr. Bakar of Georgetown, citing Malaysia, Jordan and Pakistan, in particular. Even in Saudi Arabia, one of the most conservative Muslim states, science classes are conducted in English, Dr. Sabra said.

Nevertheless, science still lags in the Muslim world, according to Dr. Pervez Hoodbhoy, a Pakistani physicist and professor at Quaid-e-Azam University in Islamabad, who has written on Islam and science. According to his own informal survey, included in his 1991 book "Islam and Science, Religious Orthodoxy and the Battle for Rationality," Muslims are seriously underrepresented in science, accounting for fewer than 1 percent of the world's scientists while they account for almost a fifth of the world's population. Israel, he reports, has almost twice as many scientists as the Muslim countries put together.

Among other sociological and economic factors, like the lack of a middle class, Dr. Hoodbhoy attributes the malaise of Muslim science to an increasing emphasis over the last millennium on rote learning based on the Koran.

"The notion that all knowledge is in the Great Text is a great disincentive to learning," he said. "It's destructive if we want to create a thinking person, someone who can analyze, question and create." Dr. Bruno Guideroni, a Muslim who is an astrophysicist at the National Center for Scientific Research in Paris, said, "The fundamentalists criticize science simply because it is Western."

Other scholars said the attitude of conservative Muslims to science was not so much hostile as schizophrenic, wanting its benefits but not its world view. "They may use modern technology, but they don't deal with issues of religion and science." said Dr. Bakar.

One response to the invasion of Western science, said the scientists, has been an effort to "Islamicize" science by portraying the Koran as a source of scientific knowledge.

Dr. Hoodbhoy said such groups had criticized the concept of cause and effect. Educational guidelines once issued by the Institute for Policy Studies in Pakistan, for example, included the recommendation that physical effects not be related to causes.

For example, it was not Islamic to say that combining hydrogen and oxygen makes water. "You were supposed to say," Dr. Hoodbhoy recounted, "that when you bring hydrogen and oxygen together then by the will of Allah water was created."

Even Muslims who reject fundamentalism, however, have expressed doubts about the desirability of following the Western style of science, saying that it subverts traditional spiritual values and promotes materialism and alienation.

"No science is created in a vacuum," said Dr. Seyyed Hossein Nasr, a science historian, author, philosopher and professor of Islamic studies at George Washington University, during a speech at the Massachusetts Institute of Technology a few years ago. "Science arose under particular circumstances in the West with certain philosophical presumptions about the nature of reality."

Dr. Muzaffar Iqbal, a chemist and the president and founder of the Center for Islam and Science in Alberta, Canada, explained: "Modern science doesn't claim to address the purpose of life; that is outside the domain. In the Islamic world, purpose is integral, part of that life."

Most working scientists tend to scoff at the notion that science can be divided into ethnic, religious or any other kind of flavor. There is only one universe. The process of asking and answering questions about nature, they say, eventually erases the particular circumstances from which those questions arise.

In his book, Dr. Hoodbhoy recounts how Dr. Salam, Dr. Steven Weinberg, now at the University of Texas, and Dr. Sheldon Glashow at Harvard, shared the Nobel Prize for showing that electromagnetism and the so-called weak nuclear force are different manifestations of a single force.

Dr. Salam and Dr. Weinberg had devised the same contribution to that theory independently, he wrote, despite the fact that Dr. Weinberg is an atheist while Dr. Salam was a Muslim who prayed regularly and quoted from the Koran. Dr. Salam confirmed the account in his introduction to the book, describing himself as "geographically and ideologically remote" from Dr. Weinberg.

"Science is international," said Dr. El-Baz. "There is no such thing as Islamic science. Science is like building a big building, a pyramid. Each person puts up a block. These blocks have never had a religion. It's irrelevant, the color of the guy who put up the block."