the Arab World IN THE CLASSROOM

CENTER FOR CONTEMPORARY ARAB STUDIES • GEORGETOWN UNIVERSITY TEACHING MODULE NO. 1

The Contributions of Arab Civilization to

Mathematics and Science

By JULIE PETEET

Introduction

> From the second half of the eighth to the end of the eleventh century, Arabic was the scientific, the progressive language of mankind .... When the West was sufficiently mature to feel the need of deeper knowledge, it turned its attention, first of all, not to the Greek sources, but to the Arabic ones.
> —George Sarton. *Introduction to the History of Science,* 1950.

During the Arab age of enlightenment, from the 7th to the 13th centuries A.D., the arts and sciences flourished under the patronage and encouragement of the Islamic Empire. The intellectual endeavors and achievements of this period have had a lasting impact on the course of scientific thought throughout the rest of the world. The Arabs incorporated Greek, Indo-Persian, Sanskrit, and Syriac science, methods, and techniques, embarking on a translation movement of Greek scientific texts into Arabic.

From the 12th century to the Renaissance, European scholars translated Arabic scientific treatises into Latin. In most Western universities, Arabic texts on mathematics and medicine, translated into Latin, formed the basis of scientific thought and pedagogy for the next several centuries. Yet the Arabs accomplished more than just translations. Aside from transmitting Greek science and thought to Western Europe, they expounded upon, furthered, and enriched the Greek scientific and methodological heritage. The Arabs also gave the world of science and learning three contributions of lasting significance: the university, the observatory, and the hospital.

Contrary to the common assumption that religion is not conducive to scientific inquiry and experimentation, Islam provided the stimulus for a number of innovative discoveries, and was the aegis under which art and science flourished. With the spread of the Islamic Empire, beginning in the 7th century A.D., the Arabic language acquired the status of *lingua franca* of the arts, sciences, literature, and diplomacy, and the Islamic cities became centers for the cultivation and teaching of the sciences and arts.

With the Islamic/Arab conquests in the 7th century A.D., a process of cultural assimilation began. Those people who came under Arab rule adopted the Arabic language, Islam, and much of the culture of the Arabs, while the Arabs in turn adopted many of the cultural traditions, skills, and knowledge of the various peoples with whom they interacted.

When we speak of "Arab science," we mean that Arabic was the language of science and scholarship, and it was under the encouragement and patronage of the Arab Caliphs that science, art, and literature thrived and prospered. The Islamic Empire brought together peoples of various ethnic, linguistic, and religious groups, but they shared a commonality in that Arabic was the language of learning. Although scientists worked under the patronage of the Caliphs and used the Arabic language, not all of them were Arabs or Muslims. Some were Persians and Indians; many were Arab Christians and Jews.

Medicine

It is difficult to imagine the scientific advancement of Western medicine without recognizing its Greek and Arab foundations. The Arabs were transmitters of Greek scientific thought to the Western world. In the 9th century A.D., Arab scholars, led by Hunayn bin Ishaq al-'Ibadi (809-873), collected, translated, and wrote extensive commentaries on Greek science texts enabling them to be adapted for use in Western institutes of medical learning.

The Arab contribution to medical knowledge, however, extends far beyond that of translation and transmission of Greek knowledge. Arab physicians are credited with many discoveries of their own as well as further developing the Greek, Persian, and Sanskrit medical writings.

Physicians of the Islamic Empire followed a holistic approach to medicine and disease; that is, they proposed an intimate yet complex relationship between

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Medicine, *continued from page 1*

physiological (*soma*) and psychological (*psyche*) phenomena. The Persian Abu-Bakr Muhammad ibn-Zakariya (865-925), or al-Razi, one of the most prolific medical authors and best known physicians, coined the term *'ilaj al-nafsani,* or psychotherapy. In his medical practice, al-Razi applied his theories of holistic medicine using an early form of psychoanalysis. He would lead his patients into their subconscious to seek out past incidents that with time had become the cause of a physical ailment.

Al-Razi was a prolific scholar who made great strides in developing internal medicine, and some of his ideas and concepts, such as that of the patient-doctor relationship, retain their validity today. Aside from identifying smallpox and establishing its diagnosis and treatment, which gained him widespread recognition, his most significant work was the *Hawi,* a 25-volume medical encyclopedia used by students both in the East and West until the 15th century. The antiseptic use of alcohol was practiced by Al-Razi, likewise the utilization of mercury as a purgative.

Another celebrated Muslim physician was the Persian Ibn Sina, better known in the West as Avicenna (980-1037). Ibn Sina was a precursor of the "renaissance man." Like other scholars of his time, he was well-versed in many aspects of the arts and sciences. Medicine was only one among several of his intellectual interests; others were music, mathematics, geology, and poetry. Ibn Sina wrote 16 books on medicine, including the *Qanun*, an encyclopedia considered the final codification of Greco-Arab medical knowledge. The *Qanun* replaced the books of al-Razi and the Greek physician Galen; it became a standard textbook in European medical schools until the end of the 16th century.

The plague's devastation of Europe in the 14th century impelled the Arab physicians Ibn Khatib and Ibn Khatima of Moorish Spain to elaborate the concept of contagion. Only centuries later was contagion scientifically formulated and verified.

The Arab contribution to medical knowledge includes the notion of medicine as an organized, scientific profession. The first hospitals and clinics were built in the Arab world under the patronage of the Caliphs. They had separate wards for men and women, large gardens in which to grow medicinal herbs, and extensive libraries, and they offered courses in medicine. The testing and licensing of doctors and pharmacists, the concept of internship, and laws to regulate malpractice were also Arab innovations.

The Arab influence on the emergence of Western medical knowledge and the organization of medical education was of lasting value. Until the end of the 16th century, medical curricula in European universities required knowledge of Ibn Sina's *Qanun* and relied on Arab medical treatises and knowledge in general.

Under Islam, pharmacology became an independent science and profession. During the Abbasid Caliphate (mid 8th to mid 13th centuries A.D.), there were 800 privately-owned pharmacies, as well as those that were an integral part of large hospital complexes. Pharmaceutical preparations were scientifically tested, manufactured, and sold. Extensive treatises were written listing the properties and various uses of a multitude of herbs and medicinal plants. Incidents of poisoning encouraged pharmacists to translate and develop Greek texts on antidotes.

Physics

In the Arab world, physics, the foundations of which were laid by the Greeks, is associated with the Iraqi-born scientist Ibn al-Haytham (965-1030), author of the classic *Book of Optics,* who made substantial contributions to our knowledge of optics and scientific methodology.

Ibn al-Haytham's theory of optics, quite different from any preceding it, was based on his study of light rays. He was the first to determine that light travels in a straight line, weakens as it moves away from its source, and radiates in every direction. A pioneer in physics, Ibn al-Haytham was also an innovator in the use of the scientific method, establishing the basic principles of experimentation. His experiments originated from a desire to test his hypotheses on light rays.

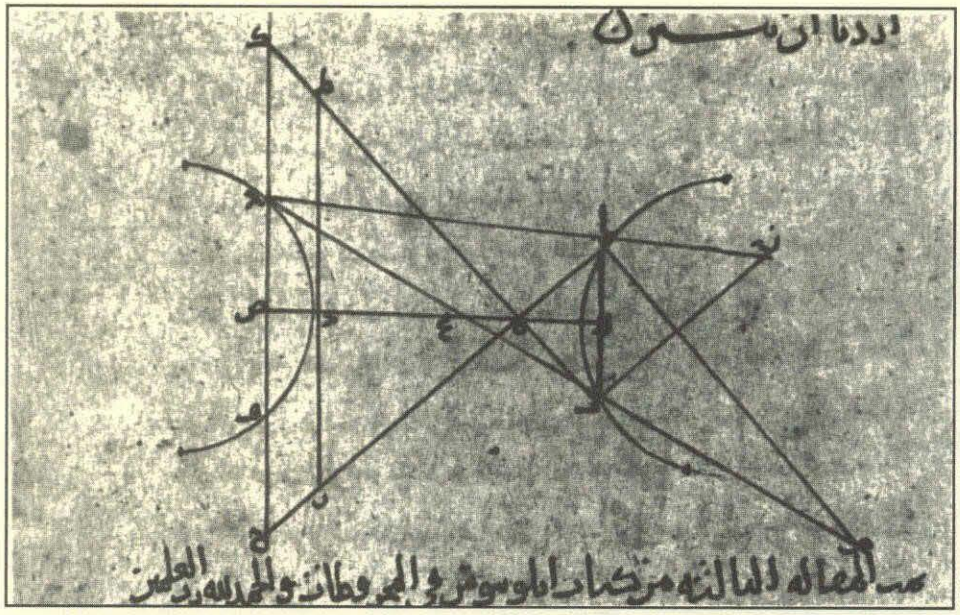
Modern optics owes much to Ibn al-Haytham's discovery of the principle of magnification. Based upon experimentation, he concluded that magnification was not an inherent property of glass, but the result of the refraction of light rays at the point of contact between glass and air. Thus, he determined that the curvature of a lens causes magnification.

Chemistry

Alchemy, from the Arabic word *al-kimiya,* or chemistry as we know it in English, was studied by the Arabs as early as the 7th century A.D. Arabic texts on chemistry were translated into Latin and served as standard texts in European institutes of learning. Indeed, many scientific words in Latin were simply transliterations from the Arabic; examples include alchemy, camphor, saffron, talc, elixir, and borax. The Arabs introduced the concept of objective experimentation, replacing speculation as methodology.

Theory and experimentation in chemistry were greatly advanced by the Iraqi Jabir ibn Hayyan in the 8th century A.D. Along with his studies in the transmutation of metals, Jabir discovered red oxide, hydrochloric acid, nitrate of silver, bichloride of mercury, sal ammoniac, and ammonium of chloride. He is, however, best known for his discovery of two principal operations of chemistry: calcination and reduction.

Although al-Razi was a physician by profession, he was also well-versed in logic, ethics, philosophy, mathematics, music, and chemistry, as were many scholars of this era. His contributions to the science of physics are substantial. In addition, he was the first to classify systematically the facts of chemical substances and reactions, and to describe the equipment used in chemical experimentation.



One of Ibn al-Haytham's diagrams from a treatise on mathematics and optics.

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Mathematics and Astronomy

In the 9th century A.D., Muhammad ibn Musa al-Khawarazmi, the father of Arab mathematics, introduced the Hindu numerical system to the Arab world, from whence it was subsequently conveyed to the West. The zero and the decimal system were transformed into a simplified mathematical system by the Arabs. Europeans were hesitant, and indeed, scornful of the concept of zero. Yet later scientific achievements in the West would have been hindered had the Roman numerical system continued to form the basis of mathematics. In Roman numerals, for instance, the number 1843 requires the use of ten digits: MDCCCXLIII; whereas in Arabic numerals, the system that we use today, only four digits are needed.

Algebra (*al-jabr* in Arabic) is another major Arab contribution to mathematics. Islamic law had much to do with the invention of algebra. The *Quran*, the holy book of Islam, stipulated inheritance laws based on the precise division of property among heirs. Al-Khawarazmi's attempts to formulate a mathematical system to divide land led him to the invention of algebra. His textbooks were standard issue in Europe until the 16th century, introducing algebra and its name into European scholarship. Two centuries later, the Persian Omar Khayyam, better known in the West as a poet, built upon the Greek legacy and carried algebra a step further into geometry. Trigonometry was an Arab invention, established as an independent discipline of pure mathematics by the work of Nasir al-din al-Tusi.

Certain religious obligations incumbent upon practicing Muslims underlay Arab improvements in astronomy. One of the five pillars of Islam calls for prayers to be said five times a day facing in the direction of the holy city of Mecca. Arab scientists began to study the stars in order to determine the required direction that people must face while praying; they also needed to calculate the direction in which mosques should be built. Another of the pillars of Islam calls upon Muslims to fast from sunrise to sunset during the month of Ramadan. To pinpoint the exact moments of sunrise and sunset requires a specialized knowledge of astronomy. In Palmyra, Syria, the Caliph Ma'mun (813-833) constructed the first observatory where the astrolabe, an instrument to observe and calculate the position of stars, was developed; with time, scholars determined the length of a degree and thus established longitude and latitude. Al-Biruni (973-1048) speculated that the earth rotates on its own axis, anticipating the later discoveries of Galileo.

The Muslim obligation to pray five times a day, facing Mecca, and the Islamic practice of making the pilgrimage to this holy city, which brought people from the far-flung corners of the Muslim world, necessitated further elaborations in geography and astronomy. Moreover, Arab trade and exploration to China in the east, the Atlantic in the west, Africa in the south, and Russia in the north stimulated advances in cartography and astronomy.

The materials used to research this module are Hayes (1983), Hitti (1970), and Macron (1980). Full citations appear in *Suggested Resources*.

Suggested Resources

Arab Civilization. Washington, D.C.: League of Arab States, Arab Information Center, n.d. Complimentary teaching packets available. To order call 202-265-3210.

Shabbas, Audrey and Al-Qazzaz, Ayad, Eds. *Arab World Notebook, Secondary School Level*. Berkeley, CA: Najda, 1989. Order from: 1400 Shattuck Ave., Suite 7, Berkeley, CA 94709.

Hayes, John R., Ed. *The Genius of Arab Civilization: Source of Renaissance* (second edition). Cambridge, MA: MIT Press, 1983.

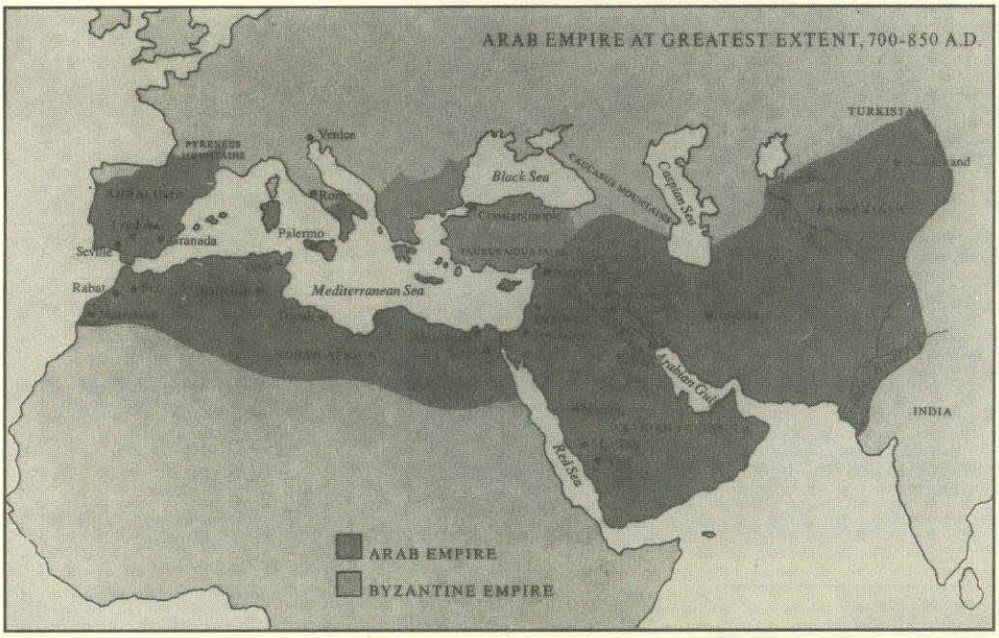
Macron, Mary. *Arab Contributions to Civilization* (ADC Issues, No. 6). Washington, DC: American-Arab Anti-Discrimination Committee, 1980.

Nasr, Sayyed Hossein. *Science and Civilization in Islam*. Cambridge, MA: Harvard University Press, 1968.

Rodinson, Maxime. *The Arabs*. Translated by Arthur Goldhammer. Chicago: University of Chicago Press, 1981.

Sabra, A.I. *Theories of Light, from Descartes to Newton*. New York: Cambridge University Press, 1981.

"Science: The Islamic Legacy." *Aramco World* (magazine) Special Issue Reprint. May–June 1982. Order from: Aramco Services Co., Attn. Public Affairs, Circulation Assistant, P.O.B. 2106, Houston, TX 77252-2106.



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Classroom Activities

These questions can be used for a written examination or as a quiz for class discussion. Possible answers are in *italics* for the teacher's use.

• Discuss or write a short essay on the role of the Arabic language in the development of math and science in the Arab world. *Essays should focus on Arabic as the* lingua franca *of the era, and the use of Arabic by non-Arab Muslims and non-Muslim Arabs.*

• Write the following Arabic numbers in Roman numerals: 8, 7, 146, 333, 1,765, 1,984, 650, and 2,492, and compare the number of digits needed in Roman numerals with those needed in Arabic numbers. *Students should be supplied with a chart of the Roman numerals.*

• Write a short essay describing the role Islam and the Caliphs played in the development of math and science. *Essays should include references to the need for more precise mathematical formulations so that Muslims could properly perform Islamic religious obligations, and to the Caliphs' role as sponsors or patrons of the sciences.*

• Describe the translation movement during the Arab age of enlightenment and its impact on the course of learning in the Western world. *Points should include translations of and commentaries on Greek, Sanskrit, Persian, and Syriac texts and their transmission to the West through Arabic-Latin translations.*

• Give as many meanings as possible to the term "Arab science." *Definitions should include Arabic as the language of the sciences; Arab rulers' patronage of the sciences; the Arab world as the center of learning during this era.*

• Each of the following people made important scientific discoveries or contributions. Who were these men and what were their contributions?

Al-Razi
Ibn Sina
Ibn al-Haytham
Al-Khawarazmi
Jabbir ibn Hayyan

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