Abu Ja'far Muhammad ibn Musa al-Khwarizmi

Abu Ja'far Muhammad ibn Musa al-Khwarizmi (c. 780 – c. 850) was a mathematical pioneer who influenced mathematical thought to a greater degree than any other medieval writer. His name indicates that he was "Muhammed, son of Musa, father of Jafar, from Khwarizm." Today, he is referred to as simply al-Khwarizmi (or some variation on this spelling). We know almost nothing of his life except that he was born at Khwarizm (now Kheva) a town south of the river Oxus in Persia in present day Uzbekistan. al-Khwarizmi's family migrated to a place south of Baghdad sometime later.

Al-Khwarizmi flourished under the reign of al-Mâmûm, the caliph of Baghdad from 809 to 833, who like his father Harun al-Rashid (whose court was featured in the *Tales of the Arabian Nights*) was a great patron of learning. Al-Mâmûm erected an observatory and built the first library to be established since the time of the Library of Alexandria. He found an academy called "Da'rul Hikma" (the House of Wisdom), whose main function was to translate foreign books. To this end al- Mâmûm invited the famed physicians, scientists, mathematicians, astrologers, historians, poets, lawyers, muhaddiths (experts on Hadith) and mufassirs (commentators on the Quran) from all over the world to accept his patronage and devote themselves to the pursuit of learning and original thinking. Among these members of the academy was al-Khwarizmi who served as the caliph's librarian.

Although his native language was Persian, al-Khwarizmi published most of his works in Arabic, the scientific language of the time and place. Al-Khwarizmi's approach was systematic and logical, not only in bringing together the prevailing knowledge in various branches of science but also making his own original contributions. He revised and corrected Ptolemy's work in geography and supervised 70 geographers in making the first map of the world. In addition, he wrote on mechanical devices such as clocks, sundials and astrolabes. He made a trip to Afghanistan and perhaps India where he became acquainted with what later would be called the Hindu-Arabic number system. On his return he wrote *Algoritimi De Numero Indorum* (its Latin title, provided by either Robert of Chester or Adelard of Bath sometime after 1240) describing these symbols, fully aware of their value and importance. It wasn't until the 14th century that the symbols for the ten digits of the system, including zero, began to resemble their present shape. These numerals were not welcomed everywhere. As late as 1299, the Italian commercial center Florence had a law forbidding their use. Some claim this is one of the reasons that when a person writes a check, the amount is expressed in two ways, one with the numerals and one written out in words.

Al-Khwarizmi was an acclaimed astronomer and creator of accurate astronomical tables, but he is best known for giving the world the word "algebra." It replaced the Greek word "arithmetike" or its Latin equivalent "arithmetica" as the title for the Science of Numbers and comes from the title of his second book on the treatment of equations. He called his book *al-Kitab al-mukhtasar fi Hisab al- jabr w' al muquabalah*, which means "The Compendious Book on Calculation by the Restoration and the Opposition." This is a reference to the two main processes employed in solving equations. "Restoration" refers to the combining of terms in the equation involving the unknown quantity. "Opposition" is the final stage of the process, when the unknown quantity "faces" (that is, is equal to) some number.

His book was written entirely in prose without access to any of the symbols in use today. The treatise is divided into five parts. In the first, al-Khwarizmi gave rules for the solution of quadratic equations. He considered only real and positive roots of equations, but, as did the Greeks, realized that each quadratic equation has two roots, possibly equal. In the second section he gave geometrical proofs for his rules. In the third section he considered the product of expressions of the form $(x + a)$, $(x - a)$, $(x + b)$, and $(x - b)$. In the fourth section he stated the rules for addition and subtraction of expressions involving the unknown, its square, or its square root, gave rules for calculating square roots, and some theorems involving square roots. In the last section he offered problems that algebra students of today might well recognize. Al-Khwarizmi made no distinction between arithmetic and algebra. For a long time, his arithmetic was long known as algorism, or the "art of Al-Khwarizmi," whence comes the word algorithm.

Al-Khwarizmi's book was translated into Latin with the title *Ludus algebrae et almucgrabalesque*, which means "The school of al-jabar and al-muquabalah". Eventually this lengthy title was reduced to the familiar word "algebra." Al-Khwarizmi's algebra is clearly a milestone in the history of mathematics. It is safe to say that subsequent Arabic and early medieval works on the theory of equations were founded on it, and through it the Hindu-Arabic system of decimal numeration was introduced into the West. *Al-jabr* found its way into Europe through the Moors who conquered Spain. During the Middle Ages it was usual for a Spanish barber to call himself an *algebrista*, or bone-setter, since barbers not only gave shaves and trimmed beards, they provided the medical services of bone-setting and bloodletting. Recall that *al-jabr* means "restoration" and one can see the connection. As late as 1565 English writer J. Halle wrote "This Araby worde Algebra sygnifyeth as well fractures of bones as sometyme the restauration of the same."

Al-Khwarizmi's books constituted the university textbooks until the 16th century. His astronomical tables, the first in Muslim history, containing not only the sine function but also the tangent, were translated into European languages and Chinese. The importance of al-Khwarizmi and the Muslim contribution to mathematics during a period in which Europe experienced the "Dark Ages" in science and mathematics cannot be emphasized too much. As Ali Abdullah al-Daffa wrote in *The Muslim Contribution to Mathematics*, 1977

"The Muslims not only created algebra, which was to become the indispensable

instrument of scientific analysis, but they laid the foundations for methods in modern

experimental research by the use of mathematical models."

Quotation of the Day: In *al-Kitab al-mukhtasar fi Hisab al- jabr w' al muquabalah*, its author asserted that the purpose of the book was to

teach: "… what is easiest and most useful in arithmetic, such as men constantly require in cases of inheritance, legacies, partition,

lawsuits, and trade, and in all their dealings with one another, or where the measuring of lands, the digging of canals, geometrical

computations, and other objects of various sorts and kinds are concerned." - Al-Khwarizmi