Algebra and Algorithms:

Restoring Attribution to al-Khwarizmi for his Mathematical Discoveries

Aboudi Rai

In the candlelit quarters of his library, al-Khwarizmi lays his stylus alongside the dust board which bears his latest discovery. A compulsory checking of the numerals outlined between piles of dust raises his heartbeat up into his ears. Realizing he has proven a method for solving any and all quadratic equations, he fretfully searches for his bamboo pen and papyrus to begin copying over what only he and his contemporaries in the House know will change the world—a world that would uphold these ideas for centuries with little credit given to the mind which conceived them.

He stumbles upon his pen, only to hear the *Athan* (Islamic call to prayer) echoing throughout the halls. He decidedly defers his transcription and begins walking toward the sound of success. Stopping at the final bookshelf before the door, his finger delicately pulls out a copy of the Quran by its binding, decorated with divergently complex, yet soothingly uniform geometric patterns. In pursuit of divine appraisal for his discovery, he flips to the 58th chapter, glides his finger to the 11th verse, and recites in a breathy, accented Arabic tongue: "Allah will elevate those of you who are faithful, and 'raise' those gifted with knowledge in rank. And Allah is All-Aware of what you do."[1]

The House of Wisdom

The remarkable work of al-Khwarizmi was not solely a consequence of his genius, but a product of the institutional investment in his mind. In the late ninth century, nearly half a millennium before the Renaissance, a scholarly movement was burgeoning from a city which today is known far more for its bombshells than its books: Baghdad. At the epicenter of the Muslim world, bookended by the Atlantic and the Indus, sat the House of Wisdom, translated literally from the Arabic *Bayt al-Hikmah*. It was an academic institution to which, at the time, parallels could not be drawn from contemporary civilizations, and today, can only be drawn from the world's most esteemed universities. The House was founded by Caliph al-Ma'mun, who was considered one of the most scientifically geared rulers of the fledgling *Ummah* (Muslim world), having memorized the entire *Quran* at an early age and studied under the greatest scholars of his time.[2,3] During his reign, al-Ma'mun was dually presented with an opportunity and a conundrum: he had access to the greatest thinkers of the vast, culturally disparate lands under his rule and their aggregated scholastic corpora; and yet, few scholars could benefit from each other's work due to the language barriers innate to a society

PC: Juli Kosolapova from Unsplash

united by its multiethnic religion.

A translation movement ensued thereafter to address this knowledge bottleneck. Arabic, being the language of the *Quran* and thus the Muslim world's de facto lingua franca, was designated as the target language for the books that would populate the House library's towering stacks.[2] Ancient texts in languages including Greek, Syriac, and Persian in disciplines such as medicine, mathematics, and astronomy were translated into Arabic for direct access by appointed scholars of the House.[4] Al-Ma'mun's vision of a utopian empire that was built upon a pursuit of knowledge was underscored by his lavish patronage. It is even said that he offered a book's weight in gold to the scholar who translated it into Arabic.[2]

What was intended only as a consolidation of preexisting discoveries later served as a crucial bridge of human knowledge. Many of the ancient Greek works upon which European discoveries were based came from their Arabic translations.[2] And while it is forgivable of the West that the Muslim translations of ancient texts were stripped of their preservative context in favor of their content, their cursory accreditation of novel Muslim discovery is less so. Indeed, one would be remiss to not acknowledge the scholastic contributions that were natively incubated within the walls of the House, most of which were pragmatically oriented insofar as the implementation of Islamic daily affairs required. Systematic computational methods for the Islamic calculation of inheritance, water-powered clocks to determine prayer times, and geographical plotting that allowed for mosques to be constructed facing the *Ka'bah* from hundreds of miles away are just a few examples.[2] The House went on to host countless scholars and facilitate diverse findings for the next half-millennium, but it was one of al-Ma'mun's first recruits whose impact far exceeded that of the rest: al-Khwarizmi.

The Persian Polymath

Muhammad ibn Musa al-Khwarizmi was a Persian polymath born around 790 AD. Often referred to by the epithet denoting his origins in the Khwarazm region (spanning present-day Uzbekistan, Turkmenistan, and Kazakhstan), al-Khwarizmi holds discoveries in the fields of geology, astronomy, and, most notably, mathematics. Just as al-Khwarizmi's scientific aptitude led to his conscription to Baghdad, the groundbreaking work he conducted during his early years at the House led to his appointment by al-Ma'mun to the high-ranking positions of principal astronomer and head of the library.[5]

Al-Khwarizmi is widely considered the "father of algebra" due to the novelty and utility of his contributions in the seminal treatise, *The Compendious Book on Calculation by Completion and Balancing*.[6] This mathematical work stemmed from al-Ma'mun's request for a systematic method of handling complex monetary exchange within his court, such as trade and inheritance, that would abide by Islamic financial law. Al-Khwarizmi took on the challenge with zeal, drawing from translated Greek and Indian works available in his library, and systemizing a method that used techniques of restoration and balancing to solve algebraic equations of the sort.[7] *Al-jabr*, appearing in the title of his text, is the Arabic word for *restoration* that al-Khwarizmi invokes in his proposed method. Its Latinization, *algebrae*, following the text's subsequent dissemination through Europe, gave us the field of algebra that remains a cornerstone of the study of mathematics today.[6]

Perhaps a more ubiquitous contribution by al-Khwarizmi is his introduction of Hindu-Arabic numerals to Europe. In his written works, Book of Indian Computation and *Book of Addition and Subtraction in Indian Arithmetic*, al-Khwarizmi outlined a systematic usage of Indian computation and arithmetic that outperformed the Roman numerals historically used in Europe. Al-Khwarizmi did not just serve as an ambassador of this Indian method of arithmetic, he improved upon it too, introducing the concept of zero—a discovery which provided the impetus for decimal number representation and their facilitated computation.[2] Latin translations of al-Khwarizmi's work on computation were disseminated throughout Europe a few centuries after their publishing. His system, which followed strictly defined rules and required only a pen and a sheet of paper, came to replace prevalent abacus-based methods in both the Muslim world and Europe. The omnipresence of al-Khwarizmi's work can be uncovered by a closer look at the name for the class of computational methods he defined: algorithm—rooted in the Latinized form of his name, *algoritmi*.[8] It would be a stretch to consider this etymological nuance a sufficient accreditation to al-Khwarizmi though, as his name is effectively undiscernible from the term that bears it. Thus, an auxiliary mention of *al-Khwarizmi*, the mathematician, should necessarily be paired with *algorithm*, his contribution.

Restoring Attribution

For the profound influence al-Khwarizmi had on mathematics during the Golden Age of Islam, the Renaissance, and his present-day impact on every secondary school mathematics class, why can we only learn of his name from a book on ancient Islamic history?

Make no mistake, Western educational institutions do deem the inventor of a scientific technique worthy of mention alongside their discovery. When physics students learn about the three laws of motion that guide our understanding of objects in space, we cannot decouple the concept from the name of its English originator, Isaac Newton. When Calculus students are adding the areas of rectangles drawn under a curve to approximate its definite integral, they are not computing just any sum, but a *Riemann sum*, named after German mathematician Bernhard Riemann. When middle school geometry students are solving for the hypotenuse of a right triangle, they apply the *Pythagorean theorem*, named after the Greek philosopher Pythagoras.

Why, then, are algebra students blindly fed *the completing the square* method of solving quadratic equations without mentioning the name of the Persian mathematician who proved it over twelve hundred years ago in a Baghdad that—unlike today—was gazed upon by the world with reverence? Academic accreditation is apparently quite selective, with a skew toward Western discovery. This is not to suggest that every discovery must credit all previous inventors involved. Rather, we should refrain from stripping a discovery of its historical context just because of its Eastern origins, whilst chalking it up to common knowledge.