Goethe, the greatest writer of the generation in which the [Great Western] Transmutation culminated, has suitably been called the "last of the universal men"; yet even he cannot have hoped to follow minutely all the technical processes in which the tools were cast which made the machines to service his theatrical innovations. [Yet] either Ibn Khaldun or Leonardo could still have done the equivalent in their time.

—MARSHALL G. S. HODGSON, The Venture of Islam

Over the course of the seven centuries between 800 and 1500, inhabitants of the Islamic lands—who were largely but not exclusively Muslims—carried their knowledge of paper and papermaking across a vast swath of Eurasia and North Africa. Had they not mediated between the cultures of the Far East and the Far West, Europeans would probably have remained ignorant of paper—as well as such other Chinese inventions as gunpowder and the compass—until the first European mariners reached Far Eastern ports in the sixteenth century. Had they not brought paper to Europe, Gutenberg's invention of printing with movable type in the mid-fifteenth century, dependent as it would have been on expensive parchment, probably would not have expanded the reading public in such a revolutionary fashion.

But, as many historians have already remarked, the Muslim lands did serve as the entrepôt for the transmission of new ideas from China across the continent to Europe. No firm boundaries divided the Eurasian and African landmass in the way that the Atlantic and Pacific oceans separated the Old World from the New, or the narrow Isthmus of Panama separated North America from South America. Over the millennia, virtually any new development or invention, whether the domestication of plants and animals, papermaking, the water-driven hammermill, the spinning wheel, or the stirrup, was gradually adopted everywhere in Eurasia within the space of four or five centuries—even more rapidly sometimes, as in the case of gunpowder weapons. Following a well-established pattern, then, paper and papermaking, both of Chinese origin, were diffused across Eurasia with the spread of Islam.

What most people have not recognized is that paper, long associated with and overshadowed by printing, was itself an engine of social, intellectual, and artistic change between the eighth century and the sixteenth. Introduced in the Islamic lands to meet the demands of a huge bureaucracy attempting to govern the largest empire the world had ever seen, paper was quickly seized on by writers on all subjects as an ideal medium—strong, flexible, light, and cheap—on which to record and transmit their thoughts. This process was encouraged not only by a societal reverence for the written word but also by ingenious and
efficient methods of duplicating and disseminating manuscripts. Writing on an enormous variety of subjects proliferated. Writers also discovered that paper could be used for recording notations other than words, which ranged—in these centuries of intellectual curiosity—from mathematical calculations to genealogical charts to battle plans.

Although much of the appeal of paper arises from its being less costly than parchment and more readily available than papyrus, the two most common writing materials of antiquity, paper was always much more expensive in medieval times than it is today. The invention of papermaking machines and the discovery of virtually infinite sources of fiber have made paper cheaper today than ever before. But even in the medieval Islamic lands paper eventually became cheap enough that ordinary people used it for purposes other than transcribing the written word. Once artisans began to use paper, it had a decisive impact on the ways in which the arts developed after around 1200. Many typical Islamic arts—Persian miniatures, Oriental carpets, the Taj Mahal—are inconceivable without the direct or indirect use of paper for preliminary sketches, encoded instructions, or measured drawings.

Muslims introduced papermaking in southern Europe in the eleventh century, and by about 1500 virtually all of Europe was making paper. The introduction of papermaking in Europe coincided with such European developments as the expanded use of documents, the acceptance of Hindu-Arabic numerals, the refinement of double-entry bookkeeping, and a certain freedom in design and drawing—all paralleling earlier developments in the Islamic lands that came with the use of paper—but the degree to which the European developments were due specifically to the introduction of paper remains to be explored.

Despite the demonstrable importance of paper, its history and role in the Islamic lands has been underappreciated for two reasons. First, papermaking had largely ceased in some of the Islamic lands by the time Europeans began writing its history in the eighteenth century. Syria, Egypt, and North Africa—those Islamic regions closest to Europe and most susceptible to European economic competition—had effectively stopped making paper and instead imported their supplies from Europe. Spain, which had been an important center of Muslim papermaking since the eleventh century, still made paper, although now the papermakers were Christians rather than Muslims, and the mills were located in Catalonia rather than Valencia.

At the other end of the Mediterranean, the Byzantines of Constantinople did not make paper, although they used it by the eleventh century. Once the city became the Ottoman capital in the fifteenth century, paper began to be made there to meet the needs of the burgeoning bureaucratic and intellectual
establishments. In spite of the Ottomans’ close ties to Europe, their papermakers followed Eastern, rather than European, papermaking techniques and traditions. European paper was still imported into the Ottoman lands; it was not, however, normally used for those books that followed Islamic, and particularly Iranian, traditions. Iranians, the first in the Muslim lands to make paper, still made it—and made it beautifully—in 1500, but within a few centuries even they succumbed to European, especially Russian, imports. India, which must have been exposed to paper in the first centuries of the Common Era, when Buddhist monks returned from China with knowledge of this material, did not make paper until the fifteenth century, when Muslim rule was established there. The Indian book industry—at least the production of books on paper—was only in its infancy in 1500, but by the end of the century, thanks to the Mughal rulers’ taste for all things Persian, Indian paper—and the associated arts of the book—was the equal of that made anywhere.

The enormous success of European, particularly Italian, papermakers in the late Middle Ages was due partly to their technical improvements in the papermaking process and partly to their aggressive marketing techniques. Compared to their West Asian and North African colleagues, Italian papermakers were able to harness waterpower more efficiently to run more efficient stampers; the resulting pulp was formed on molds made from brass wire and emblazoned with watermarks to guarantee the quality of every sheet. Nevertheless, until the invention of the Hollander beater in the late seventeenth century, techniques of papermaking remained essentially similar across Eurasia. The best Italian paper of the fifteenth century is not, for example, better than the best Iranian paper of the same period; rather, the two kinds of paper had markedly different qualities because their makers intended them to be used in different ways. The Italians’ technical prowess notwithstanding, parity reigned among the agrarian societies of Eurasia. In 1500 the Ottomans were on essentially the same cultural level as the Spanish, the Indians, and the Chinese.

The second reason that Europeans have largely ignored the history of paper in the Islamic lands is because paper has been so closely identified with printing in both China and Europe. Islam’s “failure” to accept printing has often been seen as the key moment when the rough parity that had existed among all these cultures began to dissolve and the once-great Islamic civilization began to “decline.” The reluctance of Islamic societies to adopt printing has been explained in several ways.

One explanation is practical. Arabic script was used to write not only Arabic but also Persian and Turkish, the three languages spoken (and written) over most of the vast area that comprises the traditional Islamic lands, and Arabic writing is unique in always being cursive: letters within a word have to be joined...
roller over the plate could be adjusted, and the pulp circulated constantly around the channel to be beaten as it passed between the roller and the bedplate. Powered by a windmill, a single Hollander could prepare in one hour the same quantity of pulp it took a stamper twenty-four hours to produce.

A Hollander beater

Johann Joachim Becher, a German writer on mechanics, saw this new type of pulpmill in Serndamm, Holland, on his way to England; he was the first to describe it, in a book published in 1682. By the early eighteenth century, the use of the Hollander, now powered by water, had spread to Bavaria, but it did not universally replace the old stampers. In some cases Hollanders operated alongside stampers, which were used for the initial beating of the rags.

With few modifications, Hollanders are still used, processing anywhere from a few to 3,000 pounds (1,350 kilograms) of pulp at a time, although modern mills have replaced Hollanders with huge continuous refineries based wherever possible. The script is characterized, therefore, by joins between most letters in a word, as well as by different initial, medial, final, and freestanding forms for many letters. A disconnected way to write Arabic, comparable to the individual characters in Hebrew, Greek, and Latin, never evolved. The Arabic script therefore presents typographical problems quite unlike those presented by other alphabets, or even by Chinese, with its thousands of discrete characters. Arabic type requires an extremely high level of skill in punch cutting to imitate calligraphic norms, and the compositor must also know which form of a particular letter to use when. A complete font of Arabic type, including the vowel marks required for Koranic and other vocalized texts, can easily run to more than six hundred sorts, or individual characters, plus huge quantities of leads and quadrats to be placed between vowel marks and lines. The twenty-four-point Arabic font developed for the French Imprimerie Nationale in the nineteenth century filled four cases and contained 710 different sorts (fig. 83).

In spite of the inherent difficulties, Arabic writing was printed from an early date. Some form of xylography, or block printing, was practiced as early as the tenth century, as several amulets discovered in Egypt show. Most of the known examples were block-printed on paper (fig. 84), but one example was printed on papyrus, and two were printed on parchment. Although these examples are undated, the use of papyrus and parchment suggests an early date, confirmed by the style of script and by another bit of evidence: scholars have interpreted occurrences of the obscure Arabic term *tarsh* in poems of the tenth and fourteenth centuries as references to printing amulets and charms with engraved tin plates. The
headpieces on some of the surviving block-printed amulets have designs incorporating bold lettering and ornamental motifs, sometimes in reserve, which may have been printed with separate woodblocks. Early in the twentieth century the scholar B. Moritz noted the existence of six printing plates in the ancient Khe-dival Library in Cairo, which he dated to the Fatimid period (tenth–twelfth centuries), but their present location is unknown.

Block printing was also used in Iran in 1294, when the Ilkhanid ruler Gaykhatu briefly but unsuccessfully tried to introduce block-printed paper money, which had been used in China as early as the ninth century. And some Egyptian bookbinders used block printing in the fifteenth century to decorate inexpensive leather doublures (endpapers). Contemporary Iranian leather bindings were pressure-molded using delicately carved metal stamps, so many aspects of printing technology were already available in the Islamic lands before Gutenberg’s time.

Much the way European papermakers exported their product to West Asia and North Africa almost as soon as they began making it, European printers quickly realized that printed books in Arabic could be commercial commodities, despite the difficulties of designing and producing the fonts. The earliest Arabic printed text that has survived is the Kitab salat al-sawai, a book of hours produced in Fano by the master Venetian printer Gregorio de’ Gregori in 1514. It was intended for Melkite Christians in Lebanon and Syria, but the type design is inelegant, and it was set in a clumsy, disjointed manner. Two years later, in Genoa, the typographer Pier Paolo Porro printed a trilingual Psalter in Greek, Hebrew, and Arabic with an Arabic preface.
Perhaps the most important—and most elusive—printed book in Arabic is the edition of the Koran produced by the Venetian printer Paganino de’ Paganini in 1537–38. All copies were thought to have perished in a fire until one remaining example was discovered in the 1980s in the library of the Frati Minori di San Michele ad Isola in Venice (fig. 85). The edition was probably intended as a commercial venture, but its odd typeface was quite unacceptable by Muslim calligraphic norms, and the numerous errors in the Koranic text were even more objectionable to Muslim sensibilities. As a commercial—or even an evangelical—venture, it was not a success.

Within a century of Gutenberg’s invention the first truly elegant Arabic typefaces were cut in Rome by the French type-designer and bookseller Robert Granjon, who derived his letter forms from the best scribal models and made liberal use of ligatures (joined letters). Italy remained the center of Arabic book production, particularly after Pope Gregory XIII advised Cardinal Ferdinando de’ Medici to establish the Typographia Medicea linguarum externarum—a foreign-languages press. Under the supervision of the Orientalist Giovan Battista Raimondi, the press produced a series of Arabic works, including a translation of the Bible and the Four Gospels, Avicenna’s medical canon, and the text of al-Idrisi’s geographical work Pleasant Journeys, written at the Norman court in Sicily almost five centuries earlier. In later years, other leading European typographers, such as the Englishman William Caslon and the Italian Giambattista Bodoni, were also involved in the design of Arabic fonts.

Fig. 85. Opening pages of the Koran printed by Paganino de’ Paganini in Venice, 1537–38. Library of Frati Minori di San Michele ad Isola, Venice
A second explanation for how long printing took to be established in the Islamic lands is social. Considering the extraordinarily broad interests of the Renaissance prince and Ottoman sultan Mehmed II, which included the commissioning of Greek manuscripts, the hiring of European artists, and the use of European technology, it comes as somewhat of a surprise that the sultan did not introduce printing to the Ottoman empire during his reign in the mid-fifteenth century. But resistance to printing was strong. The Ottomans did not adopt it, and the Ottoman sultans Bayezid II and Selim I even issued edicts in 1485 and 1515 specifically forbidding Muslims to print texts in Arabic characters, although Jews and eventually other minorities were permitted to print texts in Hebrew and other languages. For the next three centuries, such printing as there was in the Islamic lands was deeply dependent on European models.

The first press in Istanbul was established by Jewish immigrants following their expulsion from Spain in 1492. They may have produced their first publication by late 1493; their second book, an edition of the Torah, was printed in April 1505. A Judeo-Persian edition of the Torah, in Persian written in Hebrew characters, was published in Istanbul in 1594. Armenians began printing in Istanbul in 1567. Their press, established by two Armenians who had learned printing in Venice, was also patronized by the Latin Dominican friars; it produced six books over the next two years using fonts brought from Venice.

The story of printing in Safavid Iran followed the same course. Printing was introduced (or, technically, reintroduced) in Iran in 1629, when Carmelite friars in Isfahan received a printing press from Rome. Included were 349 Arabic letter sorts as well as two instruments to set up the type, but it is not known whether the press printed any books before 1642, when it was handed over to the Carmelites’ vicar general. The Dutch East Indies Company kept the press in storage in Isfahan until 1669, when they handed it back to the Carmelites. Meanwhile, an Armenian press was established in New Julfa, a suburb of Isfahan, in 1637, and after seventeen months of trial and error Bishop Khac’atur Kesarac’i succeeded in printing the Psalms in 1638. Although he used wooden, iron, and copper type rather than the standard lead type, his main problem, it appears, was securing good-quality paper and ink, for the finish on Iranian book paper was unsuitable for receiving impressions. He managed to print two more religious books in 1641 and 1642, but he then sent one of his pupils, Hovhannes, to Europe to learn printing. After printing a book in Armenian in Livorno in 1644, Hovhannes returned to Persia with lead type and a printing press. His intention to print the Bible was stymied by a lack of good ink, however, and the press was apparently not used until 1687, when nine books were printed.
Ottoman—and more broadly Islamic—resistance to printing can also be explained in part by the reverence that Muslims, particularly those in the ulema, or religious establishment, accord the (hand)written word. As we have seen, scribes and calligraphers enjoyed a special position in Islamic societies, and they monopolized the transmission and reproduction of texts until the eighteenth century, when Muslims began to print books. Although some members of the ulema were opposed to printing, the major obstacle appears to have been opposition from copyists. In the Ottoman capital, copyists exercised considerable economic and political power. The Bolognese scholar Luigi Ferdinando Marsigli, who had been captured by the Ottomans, sold to a pasha, and redeemed in 1682, estimated that eighty thousand copyists were working in Istanbul. The adopting of printing would have put them—and their colleagues elsewhere—out of work.

Despite this resistance, already in the 1640s the Ottoman diplomat and historian Ibrahim Pechewi, whose family had served the Ottoman sultans for generations, argued in his History that the printing press was no longer an alien thing in Turkish society and that society should accept it because of the speed with which it could produce a large number of books once the tedious work of typesetting had been done. Curiously, it was nearly eighty years after Pechewi’s death before Ibrahim Müteferrika opened the first Muslim-owned press in the Ottoman empire.

Ibrahim Müteferrika was born of Christian parents between 1670 and 1674 in Ottoman–controlled Transylvania. Educated as a Unitarian in a Hungarian theological college, he fled from Hungary when it came under Catholic Hapsburg rule and joined forces with the Hungarian resistance, which was allied to the Ottomans. Eventually Ibrahim joined the Ottoman bureaucracy and converted to Islam, becoming a member of the sultan’s Müteferrika corps, a mounted guard used for important public or political missions. Ibrahim took part in several diplomatic missions to Austria and Russia.

After visiting France as the ambassador plenipotentiary of Ahmed III to the court of Louis XV in 1720–21, Mehmed Yirmisekiz Chelebi Efendi became convinced of the necessity and permissibility of establishing a printing press in Istanbul. Joined in this endeavor by his son Said Efendi and the grand vizier Damad Ibrahim Pasha, as well as by the Shaykh al-Islam, the most important religious figure in Ottoman society, Mehmed Yirmisekiz encouraged and supported Ibrahim Müteferrika in establishing a press in Istanbul. Ibrahim made a plea for the enterprise in an essay entitled Wasilat al-tiba’ (The Device of Printing), addressed to the grand vizier. He wrote a brilliant exposition of the losses incurred by Islamic learning because the art of printing was absent among Muslims and of the benefits that the establishment of the press
would bring both to Muslims and to the Ottoman state. He cited benefits for the masses needing instruction and for the ruling classes and the benefit of perpetuating books by printing them when manuscripts could be or had been destroyed by war (as in the Christian conquest of Spain and in the Mongol invasion). Ibrahim evinced no interest in printing theologically controversial writings and therefore met no opposition from the ulema. Indeed, he got a fatwa, or legal decision, from the Shaykh al-Islam on the licitness of printing. As might have been expected, the major opposition seems to have come from copyists and calligraphers, who saw their livelihood vanishing before their eyes. Sultan Ahmad III nevertheless issued a firman authorizing the opening of a printing works to specialize in such practical subjects as medicine, crafts, and geography, but not traditional theological sciences.

Ibrahim Mütferrika was therefore the first Muslim to establish a press at Istanbul, but his Unitarian upbringing and European education undoubtedly contributed to his interest in printing. In 1731, Ibrahim wrote a book explaining the decline of the Ottoman empire vis-à-vis the European Christian states and emphasized the Ottomans’ need to take advantage of modern sciences, particularly geography and military science. Accordingly, his first attempt at printing, in 1719–20, probably done with plates and a press brought from Vienna, was a map of the Sea of Marmara, which he dedicated to the vizier; in the following years he printed two more maps, one showing the Black Sea (1724–25) and the other showing Iran (1729–30). Before the press closed in 1742, he had printed seventeen works, including dictionaries and other secular books (fig. 86). The printing of the Koran and other religious texts

FIG. 86. Opening page of the Tarikh-i rahid asladdi, a history of the Ottoman dynasty from 1660, printed by Ibrahim Mütferrika in Qustantinija (Istanbul), 1741

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remained forbidden. After his death, his foreman and son-in-law Kadi Ibrahim Efendi continued his work, publishing another seven titles between 1755–56 and 1794–95. By the end of the eighteenth century Russian Muslims had even printed the Koran.

Many of the practical and social objections to printing Arabic-script languages disappeared after the Bohemian J. N. F. Alois Senefelder invented lithography in Munich between 1796 and 1799. Unlike cold type, which required each letter to be set individually, lithography allowed the virtually flawless reproduction of entire handwritten pages. In a variation of the process, invented by Senefelder himself, a calligrapher wrote with a special liquid on specially prepared paper. The resulting text was transferred to the printing stone, from which a practically unlimited number of copies could be pulled. Unlike movable type, which took centuries to be adopted in the Islamic lands, lithography appeared there within a few decades.

Although European printers preferred to set Arabic-script languages in cold type, many readers preferred reading lithographed pages, because the results were so similar to reading a manuscript hand. Muslims produced increasing numbers of typeset and lithographed texts in the nineteenth century. Numerous illustrated editions of Persian classics, popular fiction, and translations from European languages were produced by lithography in Tehran and Tabriz from the 1840s. The introduction of Linotype in the early twentieth century and the invention of computer typesetting in the late twentieth century resolved any remaining difficulties in printing Arabic type.

In the longer view of history, therefore, the tardiness of the Muslim world to adopt printing was just a brief pause in a continuous diffusion of inventions across Eurasia. Seen in this light, the history of printing is not so dissimilar from the history of papermaking: both processes were invented in China and spread westward, all the way to the Atlantic. For paper, the route is clear: Europe adopted it from the Islamic lands. For printing, any relation between Gutenberg’s invention to earlier uses of movable type in China remains to be established. In any case, printing diffused from Europe to the Islamic lands. The hiatus between Gutenberg’s invention in the 1450s and the beginning of printing in West Asia some three centuries later was not crucial, primarily because Islamic society had already developed practical and effective means of reproducing and disseminating large numbers of texts. The invention of printing, therefore, did not have a decisive effect on the history of paper in the Islamic lands.

Far more important in distinguishing the histories of these two regions and establishing why the Islamic paper industry withered was the European development of a “technicalistic” attitude in the late Middle Ages. The histo-
rian Marshall G. S. Hodgson, who coined the term, defined technicalism as the expectation of impersonal efficiency through technical precision, and from the sixteenth century the development of a technicalistic approach to problems and problem solving in Europe increasingly differentiated Islamic and European societies.

If later Islamic societies were less receptive to innovation than European ones were, this attitude had not always prevailed. In late eighth-century Baghdad, Muslim bureaucrats had dealt with insufficient quantities of writing material by adopting and producing paper. The early Abbasid period was one of extraordinary cultural curiosity and intellectual ferment, comparable to the European Renaissance. Abbasid scholars were wide open to ideas from all around the world; paper and Hindu-Arabic numerals were among the results. By the late Middle Ages, however, the situation had changed entirely, for Islamic societies had become far less enthusiastic about reinvesting capital in technical improvements. It is at this point that Europe took the lead.

From the late Middle Ages to modern times, European societies have evinced an unprecedented technological inventiveness and an unrivaled capacity to generate economic wealth and project military power. Whereas the major Eurasian societies had enjoyed relative parity around 1500, three centuries later European culture and military might shaped the globe. The origins of this extraordinary development lie in a set of intertwined socioeconomic and cultural conditions: European societies were profoundly different from the Islamic societies of the Middle East in many ways, including family structure and the nature of government, including its connection to religion. They had also long harbored, alongside the Christian church, a belief in independent secular sources of civic and cultural values. All these factors enhanced an inherent pluralism in the European nations and generated a separation of state and church. In the late Middle Ages the initial manifestations were commercial growth, social differentiation, and the stimulation of corporate groups, especially guilds, to advance the interests of their members.

The developing sense of European pluralism, which resulted in an increasing awareness of the individual and the individual’s intrinsic worth, can be contrasted to the holistic commitment of Muslim societies to the rule of law, based in the Koran and the example of the prophet Muhammad, and to the community, known in Arabic as the umma. An individual’s obligations were defined in terms of a religiously commanded participation in the community, which was itself religiously defined.

As early as the thirteenth and fourteenth centuries in Italy, in Flanders, and along the Baltic Sea coast this new orientation was applied to technical invention, such as papermaking, and to the pursuit of material well-being,
resulting in new techniques for investment, banking, and insurance. The pluralistic tendencies were exaggerated by the Renaissance and especially by the Reformation, which drove individuals to seek worldly signs of their salvation through methodical and devoted labor. With this transmutation, people systematically subordinated all extraneous personal, emotional, aesthetic, and even ethical considerations to the demand for a patterned way of life. These beliefs resulted in a capacity for making an impersonal and unemotional commitment to the inherent norms of an enterprise and for pursuing specialized goals to their ultimate conclusion. Europeans thereby came to possess a unique form of social and institutional pluralism as well as a mentality that stressed innovation, individual worldly activity, aggressive dominance, and technical experimentation. It was these attitudes that generated the advances that gave them worldwide military and commercial supremacy in the modern era.

The origins of the print revolution in Europe lie, therefore, not simply in Gutenberg's invention of movable type but in a much larger nexus of invention and economic expansion, including the growth of German economic power, the opening of new mines in the Hartz Mountains (in Bohemia, Hungary, and Styria), the development of new metallurgical techniques, the spread of papermaking, the invention of new oil-based inks, new forms of capitalism, and an intellectual revival that made people eager to have books. A similar technicalistic attitude transformed European papermaking beginning in the late seventeenth century and differentiated its products from handmade paper produced elsewhere. The invention of the Hollander beater, which could do in one hour what it took an old hammermill a day to do, was followed at the end of the eighteenth century by the Fourdrinier papermaking machine, which, given sufficient quantities of pulp, could make an endless strip of paper of virtually any width. Meanwhile, European engineers and savants were searching for new raw materials from which to make paper and new ways to exploit them. Their efforts gave us chemical bleaches, which made previously available stocks of fiber now usable for papermaking, and methods to extract virtually limitless quantities of cellulose from trees.

The importance of printing in the great transformation of European civilization is undeniable, but paper, the material that Islamic civilization carried from China to Europe, was an even greater invention in the history of humankind. Cheaper writing materials not only made old learning more accessible but also encouraged new learning and initiated new ways of thinking and representing thought. As Alfred von Kremer realized more than a century ago and as we are only now coming to understand, the "blossoming of mental activity" made possible by paper "started a new era of civilization."