From a cultural and historical point of view the reduction in the cost of writing material, which went hand in hand with the production of paper, was of great importance. Books on parchment or papyrus were so expensive that they were available to very few. By the production of a cheap writing material, and its supply to markets both east and west, the Arabs made learning accessible to all. It ceased to be the privilege of only one class, initiating that blossoming of mental activity that burst the chains of fanaticism, superstition and despotism. So started a new era of civilisation. The one we live in now.

—ALFRED VON KREMER, Culturgeschichte des Orients

Paper, one of the most ubiquitous materials in modern life, was invented in China a century or two before the Common, or Christian, Era. Nearly a millennium passed, however, before Europeans first used the stuff, and they did not make it themselves until the eleventh and twelfth centuries. European Christians learned about making paper from the Muslims (“Moors”) who then ruled Spain and who established the first papermills in Europe. The papermakers transformed linen rags and other waste fibers into a strong and supple writing material by first beating the fibers with water-powered trip-hammers. The resultant pulp was mixed with water, gathered on screens by hand, and dried. Monks continued to copy their manuscripts on expensive parchment, made from the skins of sheep, goats, and calves, but the emerging middle class of notaries and merchants in southern Europe found paper to be a perfect medium for registers, deeds, and commercial documents, which they were producing in increasing numbers. In the late fourteenth century the German entrepreneur Ulman Stromer, who had seen papermills in Italy—themselves modeled on West Asian prototypes—established the first papermill north of the Alps, at Nuremberg (fig. 1).

European papermaking took off when Johann Gutenberg began printing books in fifteenth-century Mainz. Although Gutenberg is thought to have printed thirty-five copies of his great Bible on parchment, the remainder of the edition—perhaps two hundred copies in all—were printed on sheets of handmade paper. The subsequent print revolution was dependent on the prior existence of papermills like Stromer’s, for economics demanded that printers amortize the high costs of making the type and running the press by printing in large editions. Reams and reams of laboriously handmade paper were now needed to make the burgeoning numbers of printed books that sixteenth-century Europeans read, and to make all that paper, linen rags had to be collected, sorted, and prepared. To be a ragman was an important job. Demand for paper only increased in the following centuries as Europeans
Paper

Suspending cellulose fibers in water and then depositing them on a screen to remove the excess water yields, after drying, a fiber mat: paper. Cellulose fibers, found in the cell walls of plants, may be extracted either directly from the bast or woody parts or indirectly from rags or textile waste, such as cotton lint, left over from some other process. Paper owes its distinctive qualities of strength and flexibility to the chemical and physical qualities of cellulose \((\text{C}_6\text{H}_10\text{O}_5\{\text{OH}\})_n\), which plants make from glucose \((\text{C}_6\text{H}_{12}\text{O}_6)\), a simple sugar produced during photosynthesis. The plant links glucose molecules, which are shaped like branched rings, with oxygen atoms into an alternating pattern. Because every other ring is inverted, the cellulose molecule has weak alternating positive and negative charges along each face, and these charges allow the molecules to pack together to form microfibrils and fibers. The close physical contact between the cellulose molecules leads to hydrogen bonding, the attraction between negatively charged oxygen atoms and positively charged hydrogen atoms that gives the fibers structure and strength.

The molecular structure of cellulose

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developed new and varied uses for this versatile material—from teabags to wallpaper—and discovered new sources, particularly woodpulp, for the fiber from which paper could be made.

Even today, despite the promise of computers, we use more paper than ever before. In 1996, for example, the computer manufacturer Hewlett-Packard estimated that copiers, fax machines, and computer printers spewed out 860 billion pages in the United States alone. Laid side by side, these single sheets from countless reports, interoffice memos, and newsletters would cover approximately 200,000 square miles, or 18 percent of the surface of the United States. Were we to achieve the improbable goal of the paperless, computerized office, paper manufacturers would still have outlets for their product, for paper is now used for a myriad of other purposes, including packaging, filtering, and construction. The 1996 edition of the standard guide to the U.S. paper industry, Lockwood-Post’s Directory of Products of Pulp, Paper Mills, Converters and Merchants, lists over four hundred distinct uses for paper, ranging from abrasive backings (sandpaper) to paper yarns.

Because the introduction of paper in northern Europe in the fourteenth century was followed closely by the introduction of printing with movable type in the fifteenth, historians have tended to subsume the history of paper within the larger story of printing and the printed book. Henri-Jean Martin, in his magisterial History and Power of Writing (1994), gives the history of paper relatively short shrift, although he acknowledges its importance in his larger story. Even in China, where paper (and printing) was invented, the history of paper and the history of printing are usually considered together, as in Tsien Tuen-Hsuin’s masterpiece, Paper and Printing (1985).
Nevertheless, paper has its own story, although comparatively few historians have studied it. Of those who have, most have been specialists writing for specialist audiences. One of the first Europeans to study the history of paper was the French astronomer royal, Jérôme de Lalande, who in 1762 published a complete manual on the history and technique of papermaking, *L'art de faire le papier*. A few years later, many of de Lalande’s engraved plates showing the process of papermaking resurfaced in Diderot and d’Alembert’s *Encyclopédie*, the ambitious compendium of eighteenth-century European knowledge and technology (fig. 2). For the modern reader, the most accessible history of paper remains the classic by an American, Dard Hunter: *Papermaking: The History and Technique of an Ancient Craft* (1943; rev. 1947), which, though dated, remains in print. More recently the French author Lucien Polastron has given a comprehensive overview to the history of papermaking from its Asian origins to modern European industrial processes in his *Le Papi er: 2000 ans d’histoire et de savoir-faire* (1999).

Eighteenth-century descriptions and engravings of papermaking indicate that papermaking, like most industrial processes in Europe before the Industrial Revolution, had changed little over the last thousand years, apart from the introduction of the Hollander beater (the Dutch invention that mechanized and sped up the transformation of rags into pulp) in the late seventeenth century. From the middle of the eighteenth century, however, papermaking, like such other basic industrial processes as spinning and weaving, was transformed by several discoveries and inventions.

First, the identification of the element chlorine and its bleaching properties expanded the range of cloth (and ultimately other fibers) that could be made into white paper suitable for printing. The color of a sheet of paper was primarily dependent on the color of the fibers from which it was made. Clean white fibers made white paper, while dirty dark fibers made dull dark paper. The Swedish chemist Karl Wilhelm Scheele first prepared chlorine gas in 1774, and its bleaching properties were first demonstrated a decade later by the French chemist Claude Berthollet. The English brothers Clement and George Taylor were granted a patent covering a bleaching agent in 1792, and seven years later the Scottish chemist Charles Tennant introduced bleaching powder, a solid combination of chlorine and slaked lime, which had the same effect as the poisonous chlorine gas and could be handled and shipped easily. The powder was used extensively to bleach cloth and rags for papermaking, as well as to bleach printed and written paper for recycling. By 1829, however, reports had appeared indicating that bleaching caused paper to degrade.

Second, the invention of a practical papermaking machine meant that large quantities of paper could be made relatively easily and quickly by fewer people. After working in François Didot’s papermill at Essonnes, in France, Cellulose, the most abundant of all naturally occurring organic compounds, makes up about 33 percent of all plant material (about 90 percent of cotton and about 50 percent of wood). The plant material may be treated by moisture, heat, or beating, or a combination, to release the cellulose fibers. The stalks of flax plants are soaked in water and fermented (retted), dried, and beaten to release the fiber, which may be spun into linen thread or further processed into paper. The inner bark of kozo, which is used by Japanese papermakers, is steamed, dried, soaked, softened, scraped, washed, and cooked. These processes are skipped when materials such as rags, old ropes, or old fishing nets are used; these materials are sorted, cleaned, soaked, and left to ferment to begin breaking down the fibers.

After fermenting, the fibers, whatever their origin, are beaten in water to further break them down and make them swell and join together. During fibrillation, as this process is called, the outer layers of the fibers partially detach as microfibrils, causing water molecules (which have either a positive or a negative charge) to attach themselves to the exposed hydrogen atoms along the edges of the cellulose molecules of the microfibrils. The pulp, or “stuff,” is then said to be “hydrated,” and a mat of it is collected on a screen.
and drained. On the intertwined fibers the microfibrils form physical and chemical links. As the mat dries, the water that was attached to the outer layers of the cellulose fibers evaporates, drawing the fibers closer together and allowing the microfibrils to form the same type of hydrogen bonds with neighboring fibers that exist within individual fibers. This combination of physical and chemical bonding of the cellulose fibers gives paper its strength and flexibility.

Cotton fibers, seen under a scanning electron microscope

After the sheet is formed and dried, the cellulose in paper can continue to absorb water. Wet paper is weaker than dry paper, as anyone who has used paper towels or tried to read a wet newspaper knows. Liquids will also spread in the sheet, as in blotting paper, unless it has been coated or impregnated ("sized") with some substance, such as wax, starch, or glue, to retard penetration. Differences in fibers, processing, and finishing result in papers of

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the former soldier Nicholas-Louis Robert tried inventing a machine to speed up the process of making paper. His first attempts failed, but in 1798 he was ready to apply for a patent on a machine that made an endless strip of paper rather than individual sheets. Although the French government recognized the importance of Robert’s invention, he was forced to sell his patent to Didot, who approached John Gamble, his English brother-in-law, about building Robert’s machine in England. Gamble in turn approached the London stationers Henry and Sealy Fourdrinier, who then hired Bryan Donkin, a talented mechanic, to build a machine patterned after Robert’s, and the Fourdrinier brothers secured several English patents. Although they spent about sixty thousand pounds developing and patenting their machine, there was a flaw in the patent, and the only recognition they received was that papermaking machines are known to this day as Fourdrinier machines.

Finally, the chemical and physical analysis of paper and the discovery of cellulose led inventors to find several processes to release cellulose fibers from wood, a virtually limitless source of fiber. In 1800 and 1801 the British patent office granted the papermaker Matthias Koops a patent for the manufacture of paper “fit for printing and other useful purposes” from “straw, hay, thistles, waste and refuse of hemp and flax and different kinds of wood and bark,” but Koops’s process is now unknown, and his company soon went bankrupt. By the middle of the nineteenth century the French chemist Anselme Payen had isolated cellulose among the chemical components of wood, and in 1840, Friedrich Gottlob Keller, a German weaver, was granted a patent for a machine to grind wood to use in making paper. Although Keller’s pulp had to have an almost equal quantity of rag fiber added to give it sufficient strength to make paper, six years later, Heinrich Voelter, who ran a papermill in Saxony, bought the Keller patent and devised a method for quantity production. Simultaneously, Charles Fenerty, in Nova Scotia, began experiments to make paper from ground wood; he produced his first sheet in Halifax in 1841. The process did not come into extensive use until about 1870.

Meanwhile, in 1851 the Englishmen Hugh Burgess and Charles Watt developed a technique for pulping softwood with caustic soda (sodium hydroxide, NaOH) at high temperatures; sodawood pulp was used from 1856, but the pulp was of relatively low strength and had to be mixed with stronger fibers to make a paper suitable for printing. As early as 1857, B. C. Tilghman, an American chemist, experimented with using sulfuric acid (H₂SO₄) to soften and defiber wood, but his sulfite process (patented in the United States in 1867) was not commercially used until the 1870s, when further experiments in Europe led to its widespread adoption there and in North America.
By the second half of the nineteenth century papermakers were able to
make great quantities of cheap paper, and a veritable explosion of books, mag-
azines, and newspapers ensued. Many other uses for paper were found as well.
By 1908 the handbook of the paper industry in the United States, Lockwood's
Directory of the Paper and Stationery Trades, listed nearly two hundred uses for paper-
mill products, ranging from "album board" and "anti-tarnish paper" to "writ-
ing paper" and "yellow way-bill copying paper."

During the same years the history of paper in Europe was placed on a more
secure scientific basis when Charles-Moise Bricquet began to collect and
organize thousands of ancient watermarks—faint designs often of animals and
figures introduced into the paper during the manufacturing process—which
he found on specimens of old paper. Italian papermakers in the late thirteenth
century had been the first to add watermarks to their products, probably to
serve as trademarks and guarantees of quality, and Bricquet was able to arrange
and date them on the basis of the dated documents that were written on water-
marked papers. His massive catalogues of European watermarks outlined the
general history of the craft and remain essential reference tools to this day,
early a hundred years later.

Europeans long debated the origins of paper. Until relatively recently,
most Westerners thought that Europeans or Arabs had invented papermaking
from the ancient Egyptian technique of transforming papyrus reeds into
sheets of writing material. In the Encyclopédie, for example, Diderot differenti-
ated European or rag paper from "Egyptian paper" (papyrus), as well as from
"cotton" paper (which he believed the Byzantines had invented) and from
Chinese and Japanese paper. He believed rag paper to be a European inven-
tion and examined possible sources: Germans, Italians, or Greek refugees in
Basle. He dismissed the possibility that it came from the "Orient" or the
"Saracens" of Spain. There was some justification for Diderot's confusion: the
word paper, which is attested in English since the fourteenth century, derives via
Old French and Spanish from the Latin word papyrus, as does the French or
German papier and the Spanish papel. The Italians, on the other hand, call
paper carta, a word derived from khartes, the Greek term for papyrus. Many
common English words associated with paper and writing, such as card, cardboard,
cartography, carton, cartoon, cartouche, cartridge, cartulary, chart, and charter, also derive
from this Greek root.

For centuries Europeans had no clue that the Chinese had invented paper
long before the Arabs and that all papermaking could be traced back to China.
Consequently, when Europeans came into direct contact with the Japanese and
Chinese in the seventeenth century, they were amazed to discover paper very
much like—but, to their minds, inferior to—their own. They chauvinistically
imagined that Asians must have learned papermaking from Europeans some time in the past; they could not imagine that the truth lay quite the other way round. One Englishman, reporting to the East India Company from Patani in 1614, requested paper from Europe, even though local paper was available: “For want of paper all our books are kept in China paper, having not so much other as to write a letter to your worship; I therefore entreat your worship to remember us with books, paper and ink of which we have great need, the cock-roaches eating the China paper.”

In spite of growing European demand for paper, European merchants active in Asia rarely sent local paper back home, although they themselves used it for on-the-spot recordkeeping. One reason was that the local paper had a soft finish, unsuitable for the goose-quill pens that Europeans normally used. As Adam Olearius, ambassador from the Duke of Holstein to Persia in the seventeenth century, explained, “The best [ink] comes from the Indies, which though it be not all equally good and fine, is yet very fit for their pens, which are not made of Goose-quills, as ours in Europe are, in regard they would be too hard for their Paper, which being of Silk or Cotton, is very tender, but they make them of Canes or Reeds, and a little bigger than our Pens.”

In addition, Japan, which made wonderful paper, was largely closed to Europeans, apart from the Dutch, who alone among European powers had access to Japanese harbors for the two centuries between 1639 and 1854. The Dutch East India Company is recorded to have shipped Japanese paper only twice, however, in 1643 and 1644. It is probable that one of these lots reached Holland and was the source of the Japanese paper on which Rembrandt, the Dutch painter and printer, who was something of a fanatic about paper, printed several etchings. Otherwise, European artists did not discover the beauty and strength of Japanese paper until the nineteenth century.

Expensive handpainted Chinese wallpaper first appeared in Europe in the late seventeenth century, but other Asian paper remained a relative rarity there until the mid-eighteenth century, when the first “India paper,” made from bamboo and rice straw, was imported into Europe. In a pamphlet that appeared in London in 1797, “an ingenious Literary Gentleman, long resident in India,” proposed making paper from paut (Crotalaria juncea) or jute (Corchorus capsularis), undoubtedly because he had seen papermakers use it in India. Had Europeans been more receptive to learning from Asian papermakers, who used a wide variety of fibers extracted from grasses and the barks of several perennial shrubs, Europe’s long search for new sources of fiber from which to make paper might have met with success earlier.

The French naturalist and physicist René-Antoine Ferchault de Réaumur had observed that certain American wasps made paperlike nests from wood
filaments. In a treatise presented to the Académie Royale on 15 November 1719, he noted that rags were becoming increasingly scarce and concluded that paper could be made directly from plant fibers and even from certain woods, although he did not go on to any practical experiments. In the following decades other Europeans attempted to increase the amount of paper produced, either by making paper out of materials other than rags or by bulking up the available rag fibers with fillers such as clay. Perhaps the most dogged was the German clergyman and amateur naturalist Jacob Christian Schäffer, who published the first volume of a treatise on papermaking in 1765. In each of the five volumes he included samples of paper he had himself made from such materials as hemp, bark, straw, asbestos, cabbage stalks, wasps' nests, cattails, burdock, thistles, turf, mallow, St. John's wort, corn husks, genista, pinecones, potatoes, old shingles, reeds, yellowwood, brazilwood, and leaves of bean plants and horse chestnut, walnut, tulip, and linden trees, all with the admixture of about one-fifth cotton rags. But none was commercially viable.

The Chinese had initially used rags and other waste fibers to make paper, but they soon used only bast or woody fibers, obtained from the phloem layer of such plants as hemp, jute, bamboo, and ramie. Soon after the invention of paper, merchants and Buddhist missionaries took paper and papermaking techniques from China to neighboring lands, including Japan, Korea, and Central Asia. Specimens of very old paper have been discovered at various sites in western China, where the extreme dryness of the climate helped preserve them. In 1900 a Chinese Buddhist monk accidentally discovered a huge cache of more than thirty thousand paper rolls in a cave in Dunhuang, used between the fourth and the tenth centuries. The rolls included Buddhist, Taoist, and Confucian texts, government documents, business contracts, calendars, and miscellaneous exercises written in a variety of languages. They made up the monastery library, stored for safekeeping at a time when the government was persecuting Buddhists. A few years later, in 1907, the Hungarian-British explorer Sir Marc Aurel Stein discovered a small group of paper documents in a ruined watchtower between Dunhuang and Loulan. Written in Soghdian and dating between the fourth century and the sixth, the five almost-complete letters and several fragments probably represent the contents of a lost or abandoned mailbag. One of the letters, enclosed in a coarse cloth envelope addressed to Samarkand, about two thousand miles west of the site, shows that Silk Road merchants throughout the oasis cities of Central Asia used paper well before the coming of Islam, several centuries later.

Muslims first encountered paper when Muslim Arab armies conquered Central Asia in the eighth century. According to the eleventh-century Arab historian Thaalibi, in his Book of Curious and Entertaining Information, Chinese pris-
oners captured by the Arab commander Ziyad ibn Salih introduced paper-
making to Samarkand after the battle of Talas in 751. After that, Thaâlibi wrote,  
“paper was manufactured on a wide scale and passed into general use, until it  
became an important export commodity for the people of Samarkand. Its  
value was universally recognized and people everywhere used it.” As entertain-
ing as this story is—and it has been repeated in virtually every history of  
paper—it is unlikely to be factual. Paper had been known and used for too long  
in Central Asia to require Chinese prisoner papermakers to be on the scene.  

Nor could Muslim papermakers make paper from the same materials as the  
Chinese did. Although the earliest specimens of Chinese paper have been found  
in the arid regions of western China, paper was apparently first made in the warm  
and moist semitropical regions of southern China. The semitropical plants used  
by the Chinese did not grow in the arid lands of Central or West Asia, so paper-
makers there turned to other sources of fiber—specifically, rags from linen and  
cotton cloth. Although the Chinese occasionally extended the supply of bast  
fibers with textile waste, old cloth was always a minor component in the pulp.  
Central Asian papermakers were the first to perfect the manufacture of paper  
entirely from rags, probably after the coming of Islam. Muslims then carried this  
new way of making paper to Iraq, Syria, Egypt, North Africa, Sicily, and finally  
Spain, developing and improving the techniques of manufacture as they went.  

One important vestige of the pivotal role of Islamic civilization in the transfer  
of papermaking to Europe survives in the way we still count paper in quan-
tities called reams. Originally the term referred to twenty quires (booklets of  
twenty-four pages), or 480 sheets; a ream has 500 sheets today. The English  
word “ream” comes via the Old French raime from the Spanish resma, which itself  
comes from the Arabic rizma, meaning “bale or bundle.” Because the first Euro-
pean papermills were established when Arabic was the common language in  
much of Spain, the derivation of the word should come as no surprise.  

Still, apart from reams, the Islamic contribution to the story of paper has  
not been generally recognized. Diderot is not the only one who missed the  
connection. This neglect has several explanations. First, soon after Italians  
began making paper in the thirteenth century, they added it to their exports to  
North Africa and West Asia. Because the Italians had access to more water-
power and were eager to develop their technology, they developed a stronger  
and cheaper product than was locally available. Papermakers in the Islamic  
lands were unable to compete. By the sixteenth century paper manufacturing  
had disappeared almost everywhere in the Islamic world, except in Turkey, Iran,  
and India. By the nineteenth century most Europeans would have had no idea  
that papermaking had once been an important industry in all the Islamic lands.  

A second reason that people have bypassed the history of paper in the
Islamic lands is that it is extremely difficult to study. In contrast to European papers, whose history is established by the identification of watermarks and the dated documents or books on watermarked paper, the study of "Islamic" or "Arab" paper is obscured by the total absence of watermarks. Islamic papers were never watermarked, and they can be dated only by reference to the texts written on them and to the scripts in which the texts were written. Although many Arabic and Persian texts were dated, many more were not, and many dates—usually given on the last page of a book—are lost. Because the history of the Arabic script is still being written, even the most expert scholars are unable to agree on the date of a written document just by looking at the style of its writing.

A third reason why the Islamic contribution is underappreciated is that where Islamic civilization flourished, in the vast region between China and Europe, the introduction of printing did not follow quickly on the heels of paper, as it did in China and Europe. Although Muslims knew about printing as early as the tenth or eleventh century, and occasionally used it to make inexpensive amulets or to decorate cotton cloth, book printing came to the Islamic lands a full millennium after the introduction of paper in the late eighth and ninth centuries. Apart from Iran and Syria, where Armenian and Melkite Christians had respectively established printing presses in the seventeenth and early eighteenth centuries, there were no printing presses in the Islamic lands until the Ottoman convert Ibrahim Müteferrika established one in Istanbul in the second decade of the eighteenth century. Before it closed in 1742 he had printed maps, dictionaries, and other secular works, but the printing of the Koran and other religious texts remained forbidden. The first printed edition of the Koran was published not for Muslims but for Christian missionaries by the Venetian Paganino de' Paganini in 1538; the first Koran printed by Muslims for Muslims was not published until 1787, in St. Petersburg, followed by another in 1803, in Kazan.

Fourth, because most scholars have considered the history of paper to be a chapter in the greater history of printing and disseminating knowledge through printed books, the history of paper in the Islamic lands has not held their interest. But paper itself is a powerful medium for the transmission of knowledge, and the effects of the diffusion of paper and papermaking—normally hidden by the shadow of printing—can be seen in the enormous and revolutionary changes to such diverse realms of human activity as literature, mathematics, geography, commerce, and the arts in the Islamic lands between the eighth century and the fourteenth. Like the introduction of printing with movable type to fifteenth-century Europe, the introduction of paper to the Islamic lands spurred a conceptual revolution whose effects are still being felt today.

Finally, some of this neglect of the Islamic role in the history of paper may
be due to a pernicious tendency to disregard the seminal contributions of Islamic civilization—in this case, as a transmitter of ideas—in favor of a search for ultimate origins elsewhere. Paper may have been invented in China, but if Muslims had not brought papermaking to Spain, Europeans would not have learned about it before the seventeenth century. If Gutenberg had been forced to print his books only on parchment, they would have been almost as expensive as the handwritten manuscripts they were meant to replace, and it would have taken much longer for Europeans to realize the benefits of printing. According to J. M. Roberts’s recent book, *A History of Europe*, the impact of the world of Islam on European civilization was far greater than its impact anywhere else. Although Westerners are all too willing to accept the primacy of China in such inventions as paper, printing, and gunpowder, the vast distances that separated Europe from China, Japan, and India before the modern era meant that "few innovative ideas reached Europe from Asia . . . unless like Indian mathematics they had undergone refinement in the Arabic crucible." For the history of paper in the West, the ultimate origin of papermaking in China is, therefore, somewhat beside the point. The history of how Muslims made paper and what they did with it had, in contrast, an enormous impact on how Western civilization developed.

The importance of Islamic paper was brought to scholarly attention a century ago by the Austrian scholar Josef von Karabacek. In 1877–78 archaeologists discovered more than 100,000 documents on papyrus and paper at the Egyptian sites of Akhmim, Arsinoë, and Ashmunayn. Most were acquired by Archduke Rainer of Austria in 1884 to form the basis of the great Vienna papyrus collection, and Karabacek was appointed curator. Whereas Archduke Rainer was principally interested in the ancient papyri, Karabacek—an Arabist by training—was interested in the twenty thousand documents on paper. With the help of the chemist Julius Wiesner, Karabacek was able to perform the first technical analyses of Islamic papers and prove that they had been made largely of flax fibers from linen rags.

Although Karabacek’s research on Arab paper is still being cited a hundred years later, knowledge of Islamic history, culture, and the arts, as well as of the larger history of paper itself, has increased greatly. Since the 1950s the French scholar Jean Irigoin and his colleagues have produced pioneering work on the identification and categorization of non-watermarked papers, both European and West Asian. Irigoin’s work has been complemented since the 1970s by greater popular and scholarly interest in Islamic art, which has brought more dated examples of books and paintings to public attention. Don Baker, the English paper conservator, examined several thousand Islamic manuscripts and leaves in the course of his career. He published very few articles before his death, but the publication of his research notes by his successor, Helen Loveday,
has provided a new standard against which specialists measure their studies of Islamic papers.

The history of paper in Islamic civilization is not, however, just about the transfer of papermaking technology from China to the West and the use of rags instead of bast fiber. The introduction of paper in the eighth century had a transformative effect on medieval Islamic civilization, spurring an extraordinary burst of literary creativity in virtually all subjects from theology to the natural sciences and literature. Religious scholars collected and codified the traditions of Muhammad, which had been preserved orally following his death in 632, and committed them to ink and paper. New types of literature, such as cookbooks and the amusing tales we now know as The Thousand and One Nights, were copied on paper for sale to interested readers. Scholars and copyists translated Greek rolls and manuscripts written on parchment and papyrus into Arabic and transcribed them onto sheets of paper, which were then bound into books. As paper became more common, new scripts more suited to the characteristics of the medium were developed, and eventually the scripts were deemed appropriate for copying the Koran.

The new availability of paper also encouraged new approaches to old subjects. At the same time that paper was being disseminated across the Islamic lands, the Hindu system of reckoning with decimal numbers (what we call "Arabic" numerals) was spreading from India westward. Before the Hindu system of reckoning was introduced, people in the Islamic lands, as elsewhere, did their calculations mentally and recorded them either on a dustboard—which could be repeatedly smoothed blank as they added the sums—or by the position of their fingers ("finger-reckoning"). The first manual of Hindu reckoning in Arabic was written in the ninth century by Muhammad ibn Musa al-Khwarizmi, whose name has given us our word algorithm (via the medieval Latin algorithmus, referring to the process of reckoning with Arabic numerals). Al-Khwarizmi still did his reckoning on a dustboard, but a century later the mathematician Abu'l-Hasan Ahmad ibn Ibrahim al-Uqlidisi ("the Euclidian") had altered the Indian scheme of calculation to suit the use of ink and paper.

Like the Muslims, Christians and Jews had access to paper as soon as it was made in the Islamic lands. One of the earliest surviving examples of "Arab" paper is a Greek manuscript on the teachings of the church fathers, probably copied at Damascus around 800, only a few decades after Muslim papermakers had set up shop in Baghdad. In the nineteenth century some 300,000 documents, the vast majority of them on paper, were discovered in a storeroom (known in Hebrew as a geniza) of the Palestinian Synagogue in Fustat (Old Cairo). The Geniza documents, largely from the mid-tenth to the mid-thirteenth centuries, pertain specifically to the Jewish community but have enormous
implications for understanding medieval Islamic commercial society. The
documents show how paper supplanted papyrus, which had been used in Egypt
for four millennia, and became an indispensable medium of commercial
communication. Medieval merchants in the Islamic lands regularly used paper
for bills of exchange, orders of payment, and similar documents to foster trade
between communities located as far apart as Spain and India.

The import of European watermarked paper in the fourteenth century
caused some consternation, as some Muslims, particularly in North Africa,
were uncomfortable with writing God’s word on a surface marked with pictures
and symbols—even crosses. Elsewhere, particularly in Iran, papermaking was
at its apogee, and the production of large sheets of fine white paper in Iran
spurred a second revolution in the Islamic book, the effects of which were felt for
another two centuries there, as well as in Egypt, India, and the Ottoman empire.

Until the thirteenth century most books had been written on sheets about
twice as large as a sheet of modern office paper; the sheets were made in molds
that could easily be held between the papermaker’s hands. Larger sheets of
paper were significantly more difficult to make and consequently too expen-
sive to use freely. Even when important people, like caliphs and sultans,
needed long scrolls for documents and decrees, they had to make do with
smaller sheets pasted together. From the thirteenth century, however, the size
and quality of paper available in Iran for books and other uses increased dra-
matically, as seen in the numerous large luxury books that have survived from
this period. These extraordinary changes were probably due to increased con-
tact between Iran and China. In China papermaking techniques had improved
over the centuries in response to the development of printing there, and
beginning in the early thirteenth century the Mongol dynasties descended
from Genghis Khan ruled China, Central Asia, southern Russia, Iran, and
Iraq. The Mongol rulers of Iran even briefly (and disastrously) introduced
printed paper currency in 1294. Simultaneously, techniques for processing
the pulp improved.

The larger sheets of paper not only allowed for larger and more monu-
mental examples of the calligrapher’s art but also for books with large illustra-
tions; beginning in the early fourteenth century the illustrated book became a
major art form in the Islamic lands, eventually giving rise to what is para-
doxically known today as Persian miniature painting. In previous centuries sci-
entific and technical books had been illustrated with relatively small drawings
and paintings to clarify specific points in the text. A few literary works were
illustrated in the thirteenth century, but it was not until the fourteenth cen-
tury that large volumes of history and literature were prepared with hundreds
of generous paintings. The artwork did not simply illustrate the text but elab-
orated on it by using, for example, complex landscapes to enliven settings, or
dramatic facial expressions and gestures to portray human emotions. Although
Persian painters did not continue to use these pictorial devices in later cen-
turies, the ideal of the heavily illustrated luxury book copied on large sheets of
exquisite paper lived on for generations.

Along with the bigger size and better quality of the paper made in Mongol
and post-Mongol Iran came wider availability, which spurred an artistic revo-
lution in the Islamic lands from the thirteenth century. Architects and artists
exploited the medium, working out designs on paper and transmitting them
from one place to another. The most obvious new role for paper was in archi-
tectural plans. Builders in antiquity had sometimes used plans and drawings,
and there are occasional references to plans in the first seven centuries of
Islam, but most construction was based on empirical knowledge relayed from
one builder to another by gesture and words and from one site to another by
observation and memory. From the fourteenth century, however, builders in
the Islamic lands took full advantage of plans and drawings to supplement their
traditional skills. The result was an increased uniformity in architecture, for
written plans allowed someone working in the capital to design a building for
a provincial city he might never have visited.

The availability of paper in the Islamic lands also spurred changes in other
arts—metalwork, ceramics, and particularly textiles—for artists could create
designs on paper that artisans could apply to their work. In traditional craft
practice throughout the first centuries of Islam, the artisans had also been the
designers, working out the design of a piece as they went along. The increased
availability of paper led some artisans in the Islamic lands to work in different
ways: potters learned their designs from pattern books, and weavers learned to
decode the instructions in large cartoons or smaller graphs. Not only did this
development signal a break in the unity of artist and artisan, but it meant that
old and new designs could be attached to whatever medium the artisan chose:
similar designs, for example, might now appear on textiles, ceramics, metalwork,
and illuminated books, creating the consistency in decoration that characterizes
much Islamic art after 1400.

The consistency and repetition of messages and motifs found in the writ-
ing and arts of the Islamic lands after 1400 are usually associated with Euro-
pean culture after Gutenberg invented printing with movable type in the mid-
dle of the fifteenth century, and great portions of European society were
exposed to the written word for the first time. The long reluctance in the
Islamic lands to accept printing despite the widespread and enthusiastic
acceptance of paper indicates that the humble material may have been as
responsible for the reluctance as for the development of printing. In any
event, Gutenberg’s invention did not come out of nowhere. Although possible connections between his invention and movable type in fifteenth-century Mainz or the earlier invention of printing with movable type in eleventh-century China remain unexplained, movable type in Gutenberg’s case resulted from several other developments in European technology of the late Middle Ages, including new techniques of finely cutting and casting metal, new oil-based inks, which would stick to the metal type better than the water-based inks used for printing woodcuts, and the invention of a machine that could evenly and quickly impress the image of the composed form of type onto sheets of paper. In the end, it comes back to paper—a simple material that truly changed the course of history.