From Papyrus to Paper: Evolution of Writing Supports in Egypt

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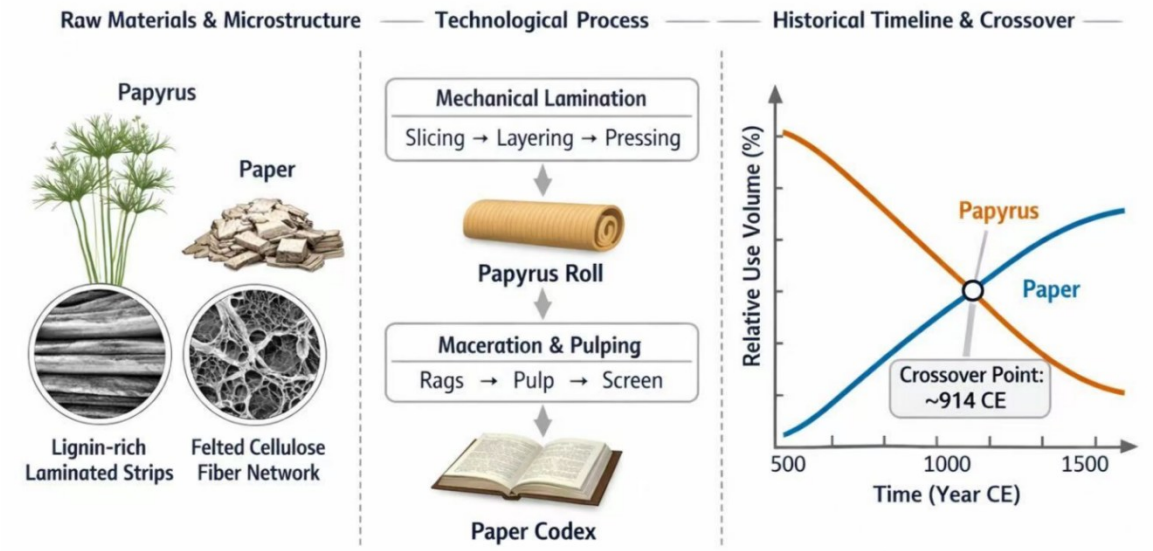
GRAPHICAL ABSTRACT



From Papyrus to Paper: Evolution of Writing Supports in Egypt

Wasim M. K. Helal [a,b] and Dina M. Elshenawi [c,*]

As the cradle of civilization, Egypt has historically been at the center of the development of writing supports, which were first developed from the local papyrus, but later gradually replaced by true paper. This paper delves into Egypt's historic change in writing materials. Used for over 4,000 years since around 3000 BCE, papyrus was a central element in the administrative and religious activities of the ancient Egyptian civilization, and the method of its production was an industry secret. The advent of true paper in the 8th century CE, which involved breaking down plant tissue to release fibers, marked the beginning of a cultural change that led to the phasing out of papyrus under Islamic rule. By the time the 12th century CE came around, the making of papyrus had essentially stopped, as paper had taken over, being both more durable and versatile. This study investigates the following: the reign of papyrus; the history and material science of papyrus; the technological shift from lamination to maceration, and comparative analysis of writing supports.

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Keywords: Papyrus; Paper; Writing supports; History of papermaking; Lignin; Cellulose

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INTRODUCTION

Materials upon which information is recorded have always been the major factor in the history of communication and documentation. There is hardly any place on earth that has such a dramatic story of the evolution of materials as in Egypt. Located at the junction of ancient civilizations and endowed with the unique ecological resource of the Nile Delta, Egypt was the cradle of the first-ever broadly used, flexible writing substrate: Papyrus. According to archaeologists, the creation of papyrus dates back to about 3000 BCE (the beginning of the First Dynasty), and it was more than just a writing material in ancient Egypt; it was the foundation of the Egyptian empire, as it was a necessity for conducting the administration and also for religious scriptures and literature for more than 4,000 years (Bagnall 2019; Nicholson and Shaw 2000). The plant, *Cyperus papyrus* L., was itself a symbol of "breath of life" and the wetland beginning of the world in Egyptian mythology (Price 2022; De Vartavan 2022). Making papyrus was a complex process of slicing, layering and pressing the pith of the *Cyperus papyrus* L. plant. This process was not only a technological breakthrough but also it resulted in a product that became the main writing medium for the entire Mediterranean world – including both the Greeks and the Romans (Krutzsch 2016).

The outstanding durability of papyrus sheets that were made from plant strips laminated together, rather than true paper, is a direct result of their material properties. These durable sheets have been mainly preserved in the dry climate of Egypt. The study of the materials by scientists today shows that the papyri from old times still have a lot of lignin, which is a very complicated polymer in a plant that gives it strength and protection from the elements. The ancients used only mechanical and natural methods, without the use of the flash alkaline solutions of today's commercial production. This may be due to the natural effectiveness of the plant's sap and the absence of such chemical reagents in those days (Bausch *et al*. 2022). Such chemical resistance speaks to the profound empirical understanding and remarkable skills in handling materials that the Egyptian craftsmen of antiquity possessed.

Nevertheless papyrus, the major writing medium, was finally countered by better technology from the East - real paper. It was a Chinese invention during the Eastern Han Dynasty (*ca*. 105 CE), paper, made by the maceration and re-formation of cellulose fibers (Hubbe and Bowden 2009; Hubbe 2025). Its introduction to the Islamic world, following the Battle of Talas in 751 CE, marked the beginning of a profound shift in documentary culture (Bloom 2001). As the center of the Islamic Caliphate's western provinces, Egypt became a crucial point of transition. The setting up of paper mills in the Middle East, Egypt among them, caused the native papyrus to be gradually replaced. The change was driven by several reasons, including the superior versatility, cheaper price, and easier obtaining of the raw materials for paper in comparison with the geographically limited and highly labor-intensive papyrus production (Shatzmiller 2018). This transition has also led to literacy, as the low cost of paper has allowed knowledge to be shared widely among groups in society. When people were given the opportunity to use paper, it literally opened the door to knowledge and the exchange of knowledge and thus a noticeable change occurred both culturally and intellectually.

The 8th to 12th centuries were a crucial time in Egyptian history that has not received the attention that it deserves. It was during this time that papyrus and paper were both used, showing the locals' compromise between sticking to their heritage and exploring new things. Historical evidence indicates that by the 12th century, the production of papyrus had essentially ceased (Nicholson and Shaw 2000). Either way, it marked not only the end of a 4000-year-old tradition but also the takeover of paper as the 'king of writing materials' (Nicholson and Shaw 2000). The changeover wasn't just about switching to a different kind of material; it signified a thorough turning point in the 'economy of information'. It opened up literacy, administration, and the flow of scientific ideas not just in the Islamic world but eventually also in Europe.

This study aims at providing a concise, interdisciplinary analysis of the evolution of writing supports in Egypt, focusing on the material science distinction between papyrus and paper, the historical timeline of their coexistence and transition, and the technological and economic factors that underpinned the eventual triumph of paper.

THE EVOLUTION OF WRITING SUPPORTS IN EGYPT

The material history of writing in Egypt is a chronicle of how technology changed over time, from stone and clay to papyrus and then to paper. Before papyrus was invented, monumental inscriptions were carved into stone, and administrative records were sometimes recorded on ostraca (potsherds or limestone flakes) or wooden tablets. These

materials were either too heavy or too limited for widespread, detailed record keeping (Bard 2015). The invention of papyrus was a huge step forward, since it made it possible to make scrolls that were portable, flexible, and easy to store.

The Reign of Papyrus

Papyrus manufacture was a carefully guarded secret and an important enterprise in ancient Egypt. It was a long, complicated process. The method included cutting the triangle stalks of the *Cyperus papyrus* L. plant, peeling off the outer rind, and cutting the interior pith into thin strips called phylirae. After that, the strips were put out side by side in two layers that were at right angles to each other, wet, and pressed. The natural sap worked as glue, and the sheet was then dried and polished. Experimental reconstructions have confirmed that the natural adhesion of the sap is sufficient to form a durable bond without additional adhesives (Krutzsch 2016). Most of the chemical constituents in ancient papyrus are cellulose and hemicellulose, but there are also a lot of lignin (up to 16% of the pith) (Bausch *et al*. 2022). The fact that lignin is a major part of wood and gives it structural strength and resistance to biological breakdown helps to explain why papyrus, which also contained lignin, stayed in such good condition in the dry Egyptian climate.

The papyrus plant, once abundant in the marshes of the Nile Delta, provided Egypt with a near-monopoly on this vital commodity, giving it considerable economic and political leverage in the ancient Mediterranean world (Nicholson and Shaw 2000). The material's dominance persisted through the Hellenistic and Roman periods, and even after the Arab conquest in 641 CE, papyrus continued to be the social administrative writing support for over a century, a testament to its established infrastructure and quality (Bloom 2000).

The Arrival of Paper

The arrival of real paper, kāghidh in Arabic, in Egypt is an important event in the history of the transfer of technology around the world. The technology for creating paper came from China, but it didn't become popular in the Middle East until Chinese papermakers were captured in Samarkand in 751 CE (Bloom 2001). The first paper mill in the Islamic world opened in Baghdad in 794 CE, and the technology quickly migrated to the west. The first documented paper mill in Africa was established in Fustat (Old Cairo), Egypt, around 850 CE (Bloom 2001). The raw material for this early Islamic paper was primarily linen and hemp rags, which were macerated into a pulp and then formed into sheets, a process fundamentally different from the lamination technique of papyrus.

The maceration process involved a large amount of mechanical energy to break the textile fibers. Different from the later European paper mills, which in the end mainly used water power, early Islamic papermaking in Egypt depended on human-powered beating. According to historical evidence, workers used trip hammers or pestle-like tools to macerate the rags (Bloom 2001). The process might have included retting, submerging textiles in water until they begin to decompose slightly, as a means of reducing the energy needed for pounding; however, there is hardly any direct evidence of retting practices at the Fustat mill. This very laborious pulping stage marks a considerable change in technology from the mechanical lamination of papyrus production. Because there was no water power infrastructure in early Islamic Egypt, papermaking was still a labor-intensive craft industry instead of a mechanized production, thus, the output volume and cost structures allowed for a gradual rather than a sudden replacement of papyrus.

The change from papyrus to paper took a long time, over a hundred years. For a while, both materials were used at the same time. Papyrus was typically employed for official documents, while paper was used for private, literary, and scientific correspondence (Ebeid 2018). But paper's advantages—its better surface for writing, its greater resistance to folding, and the fact that its raw components are relatively easy to find and replace eventually won out. By the 12th century CE, Egypt had mostly stopped making papyrus, which ended its 4,000-year reign as the best writing material (Nicholson and Shaw 2000).

Figure 1 highlights the long reign of papyrus (c. 3000 BCE to c. 1200 CE) and the critical, overlapping period of transition (c. 850 CE to c. 1200 CE) following the introduction of paper. The dating of papyrus's decline to approximately 1200 CE is documented by (Nicholson and Shaw 2000), who note that by this time Egypt had mostly stopped making papyrus. This chronological bar chart illustrates the primary use periods of major writing supports in Egypt.

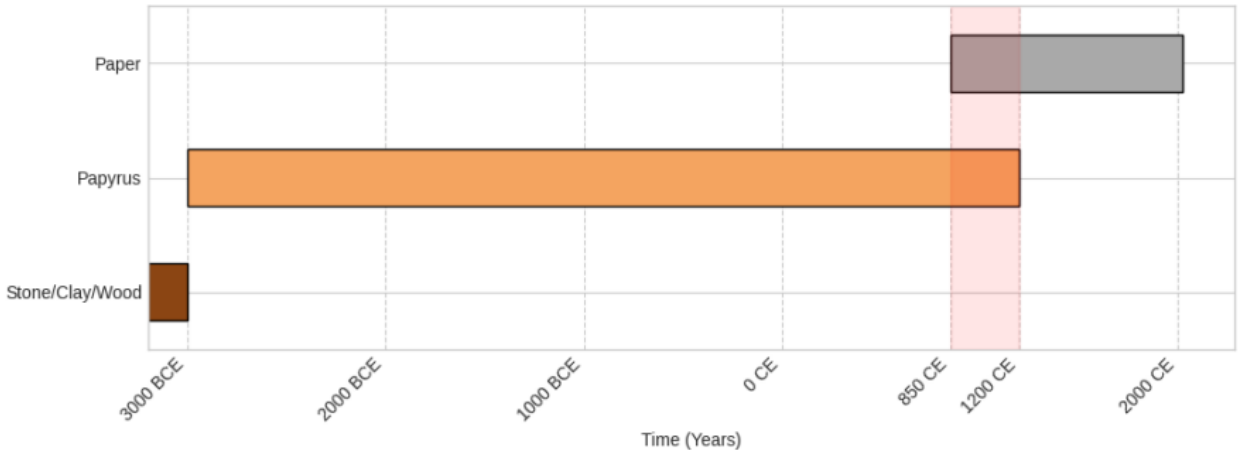

Fig. 1. Timeline of primary writing supports in Egypt

Socio-Cultural Dimensions of the Transition

The shift from papyrus to paper had a big impact on Egyptian society, going beyond just how things were made. As papyrus production decreased, it wasn't just a matter of old technology being replaced it was also the end of a craft that had been a part of Egyptian culture for thousands of years. Papyrus was special because it came from the Nile, and it played a big role in Egyptian religion and identity. When paper started to become more widely used, from the 8th to the 12th centuries, Egyptian writers and officials had to figure out how to balance keeping their traditional ways of doing things with adopting new, more efficient technologies. During this time, more people in the Islamic world were learning to read and write, thanks in part to paper being cheaper and more accessible (Shatzmiller 2018). One of the main reasons the codex, which is a book format that completely changed how humans read and organize their information, was invented is because someone discovered how to fold paper. The change brought about by the codex was so radical that it transformed completely the education system in Egypt of the Middle Ages and with the new system of education, knowledge was freely shared and preserved in a new way. When paper was used extensively, the way people looked at learning and education was revolutionized and eventually new ideas and practices could be developed. The old ways,

which were almost inseparable from the use of papyrus, were slowly replaced by the new ones. Thus, the Egyptian society was able to progress and develop. When people were given the chance to use paper, it literally opened the door to knowledge and the sharing of knowledge thus a remarkable change both culturally and intellectually happened.

Overall, the move from papyrus to paper was a significant turning point in Egyptian history, one that went beyond just a change in technology it was a shift in culture, identity, and the way people interacted with knowledge.

Ancient Papermaking and Modern Sustainability

The gradual change from the use of papyrus to paper in the past is a good example of how people can learn from history to solve current sustainability issues in materials science. The paper industry today is facing problems such as depletion of virgin fibers and the need to reduce the carbon footprint. During the medieval times in Egypt, textile waste was used to make paper, which was a new way of producing and sharing information (Balea *et al.* 2023; Pătrăucean-Patraşcu *et al.* 2025). According to recent studies, the fibers of cellulose can be recycled 5 to 7 times and still retain their mechanical properties; thus, the medieval rag-paper economy is indeed a sustainable model (Balea *et al.* 2023; Pătrăucean-Patraşcu *et al.* 2025).

Moreover, materials science studies have now backed the fact that papyrus, which is rich in lignin, has an outstanding property that allows it to be kept for a very long time (Bausch *et al.* 2022). This then brings up significant issues relating to the durability of the present media for digital storage and how sustainable is our documentation system that is constantly changing. Egyptian scribes were able to balance between the traditionalists who continued to use papyrus preservers and the early-adopters who started to use paper. Similarly, our society now is in the dilemma of choosing between paper and digital information systems. Studies in the environment regarding the degradation of papyrus wetlands have recently been done (Orodo *et al.* 2024; Assefa *et al.* 2025). These studies show that material changes go hand in hand with environmental changes; thus they link sustainability challenges of ancient times to those of the modern world across millennia. Through the experience of Egypt, it has been learned that the materials for documentation are not simply technical decisions but rather, they are the outcome of complex negotiations involving preservation, accessibility, cultural identity, and environmental sustainability. These are lessons that are as applicable to the current digital revolution as they were to the medieval transition from papyrus to paper.

HISTORICAL NARRATIVE: FROM PAPYRUS TO PAPER

The History and Material Science of Papyrus

Papyrus in Egypt dates back to the beginning of the dynasty era. *Cyperus papyrus*, which is commonly known as Papyrus, was not only used for writing materials, but in addition, other uses included making boats, ropes, and baskets, which indicates the significance of the plant to Egyptian culture and economic systems. Typically, the writing material was known to be a “gift of the Nile”.

Papyrus is a natural fiber composite material from the materials science viewpoint. When the piths of the plant are pressed together, the natural gums and starches exuded from it bind the cellulose fibers together in the formation of a sheet. Lignin is a complex phenolic polymer. Lignin is an extremely important component differing the papyrus pith from real

paper. Lignin provides strength and natural protection from UV rays and acts as an antioxidant. This is the reason why the ancient papyri have managed to maintain themselves in such a good condition in the arid climate of Egypt (Bausch *et al*. 2022).

A study indicated the presence of a significantly higher content of lignin in the ancient Egyptian papyri as compared to the modern ones, which are often treated with strong alkaline materials and bleaches in order to impart a desired yellowish color (Bausch *et al*. 2022). This physical evidence clearly reveals that the process followed by the Egyptians in their papyri production was strictly mechanical and natural, aiming at retaining its natural strength. Experimental reconstructions of ancient papyrus manufacture have confirmed that mechanical pressing alone, without chemical intervention, produces sheets with comparable lignin retention and physical properties to archaeological specimens (Bausch *et al.* 2022).

The Technological Shift: From Lamination to Maceration

The transition to paper was a shift from a composite material to a felted fibrous network. True paper is the result of a process where raw materials (rags, bark, or other cellulose sources) are macerated into single fibers which are then suspended in water. Finally, a sheet is formed by draining the water through a fine screen. This process that results in a random, interlocked network of cellulose fibers produces a material of superior quality for mass production and durability.

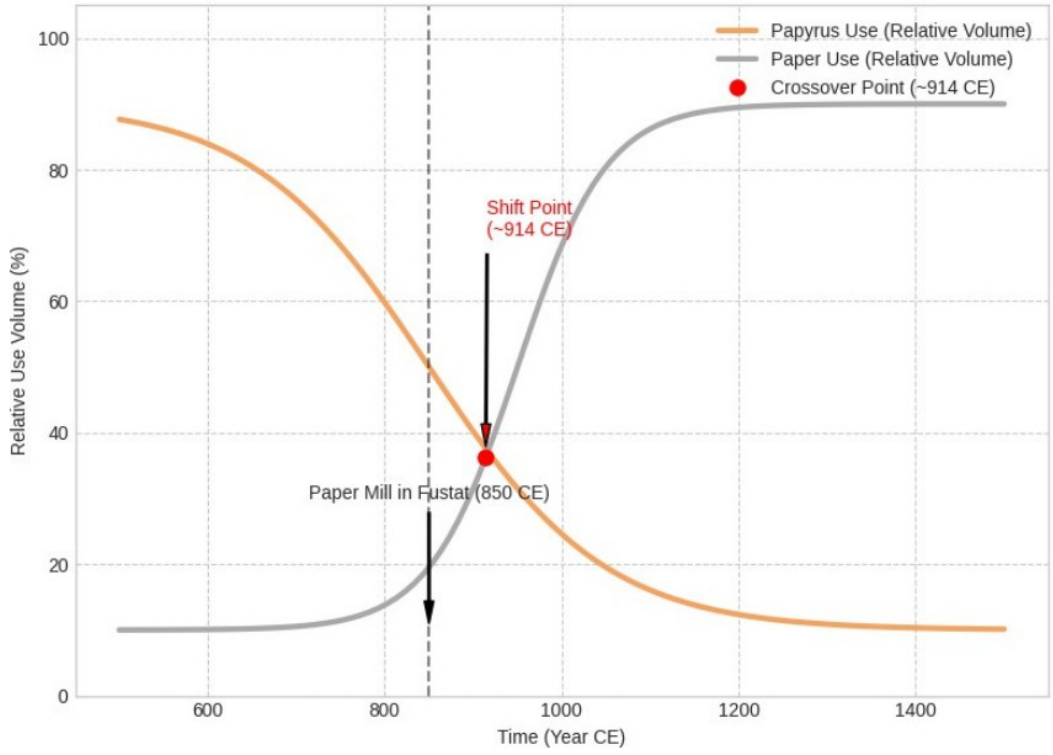

Fig. 2. Chronological shift in writing support use (500 CE- 1500 CE)

The introduction of paper to Egypt, an event that was marked by the establishment of the Fustat paper mill around 850 CE (Bloom 2001), led to a material competition era. Paper provided several key benefits:

1. Raw Material Availability: Paper can be manufactured from textiles waste (linen and hemp rags), which are plentiful, whereas papyrus production relied on the increasingly scarce *Cyperus papyrus* L. plant, which is now vanishing from the Nile Delta because of environmental changes and over-harvesting (Nicholson and Shaw 2000).
2. Versatility and Handling: Paper is more flexible, can be folded without cracking, and it is more suitable for binding into codices than papyrus that was mainly used in rolls (Bloom 2000).
3. Surface Quality: The smooth, felted surface of paper was more accepting for ink and it made possible the production of finer script and illustrations than the naturally ribbed surface of papyrus (Bloom 2001).

The phasing out of papyrus production by the 12th century CE was primarily a result of these technological and economic pressures that consolidated the position of paper as the better and more sustainable writing support for the coming globalized economy of the Islamic world.

Figure 2 visually represents the material and historical shift. It shows the inverse correlation of relative use volume for Papyrus and Paper in Egypt from 500 CE to 1500 CE.

COMPARATIVE ANALYSIS OF WRITING SUPPORTS

The transition from papyrus to paper was essentially a change in the nature of materials and how they were made. A comparative study of the three main writing materials in Egypt: Papyrus, Parchment, and Paper illustrate the technological benefits that led to paper. Parchment, made from treated animal skin, served as a durable, high-quality alternative, particularly for codices, but its high cost and dependence on animal husbandry limited its widespread use in the early Islamic period, especially compared to the plant-based materials (Nicholson and Shaw 2000).

Table 1. Comparative Material and Historical Analysis of Writing Supports in Egypt

Feature	Papyrus	Parchment (Vellum)	Paper (Early Islamic)
Primary Material Source	Pith of *Cyperus papyrus* L.	Animal hides (sheep, goat, calf)	Cellulose fibers (linen/hemp rags)
Production Method	Lamination and pressing of strips	Liming, scraping, stretching, and drying	Maceration, pulping, and sheet-forming
Dominant Use Period in Egypt	c. 3000 BCE – c. 1200 CE	Sporadic, mainly for durable codices	c. 850 CE – Present
Key Material Structure	Natural composite (laminated strips)	Collagen matrix	Felted fibrous network
Key Material Property	High Lignin content (c. 16% in pith)	High durability, excellent for codices	High versatility, superior surface for ink
Economic/Logistical Factor	Egyptian monopoly, geographically restricted, high labor cost	High cost, animal-dependent, limited supply	Lower cost, raw material (rags) abundant, mass-producible
References	(Nicholson and Shaw 2000; Bausch *et al*. 2022)	(Nicholson and Shaw 2000)	(Bloom 2001)

Table 1 clearly demonstrates the material and economic superiority of paper. Papyrus, as an invention, brought a lot of benefits but it was limited by the fact that it had to come from one place and the process of making the sheets was such that the surface ended up being ribbed, not very flexible. Paper, by contrast, used what was essentially the waste of the textile industry (old cloth) and a method that allowed for regular, large-scale production. The resulting economics together with the material's better folding and binding characteristics made it the natural successor to papyrus.

Table 2 presents several criteria by which storage stability was compared. The comparison shows that depending on the time factor, papyrus in addition to its being a historically important material is capable of lasting through the ages in excellent condition.

Table 2. Comparative Analysis of Storage Stability: Papyrus vs. Paper vs. Electronic Media

Parameter	Papyrus	Paper	Electronic Media	References
Typical Lifespan	2,000–4,000+ years (arid climate)	100–500 years (optimal conditions)	3 to 30 years (active storage); 10 to 50 years (archival)	(Bausch *et al*. 2022; Assefa, Workiye Worie *et al*. 2025)
Primary Degradation Mechanism	Hydrolysis, oxidation, biological attack (in humid conditions)	Acid hydrolysis, oxidation, light damage	Magnetic decay, charge leakage, physical degradation, format obsolescence	(Bausch *et al*. 2022; Pătră ucean-Patrașcu et al. 2025)
Environmental Requirements	Stable temperature/humidity; ultra-dry conditions optimal	18–22°C, 35–45% RH, dark storage	Controlled 18 to 20 °C, 35 to 45% RH, magnetic shielding, vibration-free	(Orodo *et al.* 2024)
Vulnerability to Climate	Extremely vulnerable to humidity/moisture; excellent in arid conditions	Moderate vulnerability; alkaline buffering provides protection	Moderate vulnerability; temperature fluctuations accelerate decay	(Assefa, Workiye Worie *et al*. 2025; Balea *et al.* 2023)
Chemical Stability	High lignin content (16%) provides natural UV resistance and structural integrity	Variable; alkaline reserve (2–3% $CaCO_3$) essential for longevity	N/A (physical/digital encoding)	(Bausch *et al.* 2022)
Mechanical Durability	Brittle; susceptible to physical damage; cannot be folded repeatedly	Good tensile strength; foldable; susceptible to tearing	Vulnerable to physical shock, magnetic fields, electrostatic discharge	(Nicholson and Shaw 2000; Pătrăucean-Patrașcu et al. 2025)
Restoration Potential	Limited; surface cleaning, consolidation possible	Moderate; deacidification, repair possible	Very low; data recovery expensive and often partial	(Bausch *et al.* 2022; Pătră ucean-Patrașcu et al. 2025)
Information Density	Low (~150 words/scroll)	Moderate (~500 pages/book)	Very high (terabytes per device)	(Pătrăucean-Patrașcu et al. 2025)
Copying Fidelity	Manual transcription errors possible	Photocopying/scanning introduces minor errors	Perfect digital copies possible (but bit rot occurs)	(Bausch *et al.* 2022; Pătră ucean-Patrașcu et al. 2025)

However, as it is very sensitive to the influence of the environment, it should be stored and maintained very carefully. Paper, which is the most common writing medium, has a limited lifespan and is susceptible to physical damage. On the other hand, electronic media provide the advantage of being easy and quick to access, but if a user does not regularly update and make backups, they may lose the data. Every medium is different and has its own set of advantages and disadvantages which determine their use for various writing and record-keeping needs.

CONCLUSION

The development of writing materials in Egypt from papyrus to paper represents an interesting case for material science, technology transmission, and economic history. Papyrus, a completely natural, plant-based paper-like product with a high lignin content, was the sole writing medium of one of the world's oldest civilizations for over four thousand years. It was a technologically isolated local product perfectly adapted to the dry climate. The introduction of paper in the 9th century CE, a material made from the interlocking of cellulose fibers only, started a radical change. The greater adaptability, cheaper manufacturing, and near unlimited raw material source of paper, turned out to be a winning combination. The switch in material and time, whereby the use of paper became more than that of papyrus around the late 10th century CE, ended Egypt's ancient monopoly and welcomed it into the globalized, more efficient technology world. This change highlights the fact that the materials of documentation are not a fixed element, but they are subjected to the same innovating and economic forces that characterize all technological history.

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