The Three P's: Papyrus, Parchment, and Paper

Cover to Cover: Exposing the Bookbinder's Ancient Craft

So omnipresent in our daily lives is paper that it's easy to take it for granted. It allows us to communicate, to teach, to illustrate and to create. It forms the newspapers, magazines and books that we read, it adorns our walls, fills our wallets, and as a tissue it is our best friend when we have a cold.

Paper has survived for centuries. It's bio-degradable and recyclable. Even its by-products can be used to improve the quality of our lives. Such is the widespread use and enduring nature of paper, that we could be forgiven for thinking its development has been simple, seamless, the result of a 'low technology' of sorts. On the contrary, the development of papyrus, parchment, and paper, the three mediums most often used for the leaves of books, has been quite radical…

Papyrus

Although not paper in the true sense, papyrus was the first writing material to assume many of the properties of what we now know as paper. Invented by the Egyptians in approximately 3000 B.C., papyrus leaves for writing were made from the papyrus water-plant which grew abundantly in the marshy delta of the River Nile. The stalks of the plant were cut just above the root and their flower heads removed. Parts nearest the root were also discarded as the middle sections were the widest and most refined for the making of large sheets. The remaining stalks were cut into pieces about 2 feet in length and split down the centre. Sections of tissue-thin strips were then laid upon a board, side by side, overlapping slightly, and covered with a thin paste of wheat flour, vinegar and muddy water from the Nile. Across this, another layer of strips was placed at right angles. The criss-crossed layers of papyrus were then dried under pressure (or hammered) and the surface finally polished with a smooth stone or shell. Ancient papyrus had little fold endurance and its tendency to crack saw it used mostly as a roll or scroll. Nevertheless, it remained a popular writing material until the beginning of the 2nd century A.D.

The Papyrus Plant

The word "paper" is derived from the Ancient Greek and Latin words 'pápuros' and 'papȳrus' (Cyperus papyrus). The papyrus plant was ubiquitous in Lower Egypt where it was carefully cultivated in marshy shallows. It was known to grow in excess of twelve feet from the water's surface and its root could be as thick as a human hand. The Egyptians would weave its stalks to construct boats, sails, mats, baskets and rope, and its bark provided cloths and blankets. It was also an important fuel source. Now virtually extinct in its native habitat in the Nile Delta, papyrus continues to grow in Madagascar and some Mediterranean areas such as Sicily and the Levant. The reintroduction of papyrus into Egypt from France has allowed locals to produce, on a small scale, some items for the tourist trade and for use by communities still residing alongside the swamps.

The Papyrus Roll

A typical papyrus roll was usually constructed of papyrus sheets of varying quality. The best sheets, from the plant's innermost pith layers, would be used for its ends, since they received the most wear and tear, while the lesser quality sheets were used for its middle sections. To add additional strength and help prevent fraying, a strip of papyrus would be glued along the ends of the roll. In some cases, each end of the scroll would be wound around a stick (called an umbicus) which had attached cords to keep the roll from unravelling. The varieties and sizes of papyrus were often named in honour of emperors or officials. This information, particularly during the Roman and Byzantine periods, was written on the first sheet of a roll and was called a protocol. The protocol often included the date and place of manufacture of the papyrus, although this was generally cut off before the roll was used. For legal documents, however, this practice was forbidden by the Laws of Justinian.

Parchment

Parchment: its translucency captured here by the black felt placed underneath.

Named after the ancient city of Pergamum in Asia Minor, parchment, as a writing medium, also antedates true paper. Although it was thought to have been in use as early as 1500 B.C., it was the King of Pergamum (197-159 B.C.) who was first credited with its invention. Developed in response to the cessation of Egyptian papyrus exports to the region, parchment offered a viable substitute, even if the process of making it was a rather messy one. Traditionally, parchment was made from the split-skin of the sheep. The wool-side of the skin was made into skiver; a soft but strong leather often used in bookbinding, whilst the flesh-side became the parchment. The skins required a great deal of washing, cleaning and scraping. They would be placed into vats of caustic lime and water where they would be left to soak for several days, at least until the animal hair had sufficiently loosened so as to be easily removed. The wet skins would then be taken out and stretched tightly, by use of leather thongs, over a large wooden frame. Here, the parchment-maker would begin scraping away the hair with a long, curved, wooden-handled knife. This scraping and tightening of the skin on the frame would continue until any irregularities had been pared away and the surface was of an even thickness. The skin was then allowed to dry on the frame, tightening and shrinking further. It was scraped and shaved again, and when completely dry, was rubbed down with fine pumice. Finally, the hair or 'grain' side was given a dusting with powdered chalk in preparation for writing. During its early production parchment was often quite thick but by the 13th century it was being scraped away to an almost tissue thinness. Prepared properly, parchment was, and still is, an incredibly durable writing surface. A good parchment is soft and thin and folds easily. Under correct storage conditions, it can last for hundreds, even thousands of years.

The Difference Between Parchment and Vellum

Anyone looking to define parchment, and especially to distinguish it from vellum, will have a challenge on their hands. There seems to be as many variations of its meaning as there are books and articles written about it. Some argue that the skins employed in making parchment are not only those of

sheep but also those of calves, lambs and kids. Others suggest that the skin of any small animal (young or old) can be made into parchment. Still others believe it was the skin from young animals, particularly calves, that was used to make vellum only, not parchment. To some extent these are all true but here's what we really do know:

- Today, the terms 'parchment' and 'vellum' are often used interchangeably to mean the skin of an animal that has been de-greased and specially treated for use either in writing or printing or in binding.
- Neither parchment nor vellum is tanned, so in a way they are not true leather. Their preparation with lime renders their surface much more paper-like; it certainly shares a similar look and feel.
- Vellum, as a general rule, is manufactured from the entire skin of the animal; the skin is not split into two layers as with parchment made from sheepskin.
- Vellum can usually be distinguished from parchment by its grain and hair marks which give rise to a somewhat irregular surface. Having been scraped so thin, parchment tends not to exhibit these characteristics.

Paper

Histoire philosophique et politique...Guillaume Thomas Raynal. 1774 Rag paper of a pale blue hue, said to be the result of coloured rags used in the papermaking process.

The invention of paper is attributed to Ts'ai Lun of China, who in 105 A.D. reported to Emperor Hoti that experiments in papermaking from fibre (likely of disintegrated cloth) had been perfected. It would be a further 500 years before the Japanese learned of this paper through communications with Korea. Sheets of it, fabricated from the bark of the paper mulberry, where introduced to the country by Buddhist monks, and by the Nara period (708 – 806 A.D.) the Japanese were making paper in nine different provenances. It took over a thousand years from its first invention for the craft of papermaking to find its way to Europe. In the 12th and 13th centuries the Spanish and Italian papermakers practiced a distinctly different process, one in which macerated linen and cotton rags were dipped in a solution of gelatine made from the hoof, horns and hides of animals. That animal glue, combined with the rags, formed an opaque, impenetrable surface which perfectly suited the European manner of writing with a quill pen.

Like their Asian counterparts, European papermakers found the hand-mould, the shallow wooden frame that was dipped into the vat of pulp, to be the most important tool in forming paper. The Chinese wove mould, comprising a square of coarsely woven cloth, held within a bamboo frame, is thought to be the first such tool. Whether it was dipped into the vat and raised up horizontally under the fibres, acting like a sieve through which the water drained, or whether the macerated fibres were poured onto it is debateable. In either case the mould, with its thin layer of matted fibres, would be

placed in the sun for drying and the paper pulled away once the moisture had evaporated. The threads that ran lengthways and those which ran at 90 degrees to them (known as the warp and woof) left an impression in much the same way that watermarks are formed in today's hand-made paper.

A collection of English proverbs. John Ray. 1678 Handmade paper with "laid-lines" and "chain lines" just visible on the pastedown.

Unlike the wove mould, which had no supports under its cloth, the laid type of mould had a distinct advantage – a sheet of paper could be removed whilst still moist, significantly speeding up the papermaking process. The laid mould consisted of two separate parts: the four-sided wooden frame with its rib supports fashioned from China fir (Cunninghamia lanceolate) or arrow bamboo (Arundinaria) and the mould cover. The cover resembled a piece of bamboo matting in which very thin, rounded strips of bamboo were placed side by side and then stitched or laced together at regular intervals with silk or flax or even animal hair, often horse. Both the frame and the cover would be dipped into the vat of macerated pulp and brought to the surface. The wet, fibrous material was kept within boundaries by the bamboo cover which had rods laced onto the two edges running parallel with the rounded strips, and by the papermaker on the left and right sides who used two wooden sticks to contain it. A piece of paper was thereby formed close to the size of the mould. When laying down the paper the matting was lifted from the frame, the wet sheet deposited flat, one sheet upon another (the under-most sheet upon a board) and then the bamboo matting rolled up from the top edge to the bottom. Every sheet of paper made in this fashion would have visible impressions or "laid-lines" and "chain-lines", the former left by the rounded strips of bamboo and the latter indentations left by the silk, flax or hair lacing which had been laced (in a chain style) over and under the bamboo strips. When papermaking began in Europe it was thought that these same moulds were used. By the 13th and 14th centuries, however, the bamboo and hair chains were being replaced with metal wires, and the hand-held sticks with a 'deckle' or fence which kept the fibres from flowing over the mould. Significant variation occurred in the distance between the number of chain lines and the laid lines per inch on the sheets of paper depending on the mould. The paper produced for the 1455 Gutenberg Bible had approximately 28 laid-lines to the inch.

In modern papermaking there exists an interesting lack of reward for the discoveries made by inventors. So many of them parted with large sums of money in pursuit of their ideas, only to fail and to have others take up the work where they left off, profiting by earlier mistakes. Experiments in papermaking from wood pulp fibre were documented as early as 1765-1772 by Jacob Christian Schäffer in his six-volume treatise published in Germany. In 1798 Frenchman Nicholas-Louis Robert invented a small paper machine. Just two years later, Londoner Matthias Koops published his book *Historical account of the substances which have been used to convey ideas from the earliest date to the invention of paper*. The book was printed on paper made from straw and it included a few leaves of paper which Koops claimed were made entirely from wood. The following year John Gamble received the earliest English patent pertaining to a paper machine and in 1802 bleached wood-pulp paper appeared in an edition of *The mathematical and philosophical works by Rev. John Wilkins*,

arguably for the first time. Despite these advances, or likely because of them, it was German weaver Friedrich Gottlob Keller who was generally credited with the discovery of the industrial process for making wood pulp paper when, in 1840, he secured a German patent for a wood grinding machine that would produce paper virtually as we know it today. In 1844, a Nova Scotian by the name of Charles Fenerty who was working independently in Halifax also announced that he had successfully manufactured white paper from spruce wood pulp.

Wood made possible the phenomenal growth of the paper industry but it brought with it significant challenges for bookbinders who had to adapt their skills to suit new processes. It was vital that they understood how the paper they were working with had been made. An appreciation of its strengths and limitations would allow them to control and, if necessary, modify their work to produce a quality book. By the mid-19th century they were binding with papers that had common, key ingredients: wood pulp fibre, filler and sizing. The fibres were hair-like particles of cellulose or other vegetable material matted together. Depending on the type of pulp used, these fibres could differ in length: long-fibred paper was stronger and more flexible and durable. The filler, such as clay or chalk, was used to impregnate the space between those fibres, giving the paper its body and opacity. The sizing was used to bind the whole mass together; it also improved the surface strength, printability and water resistance of the paper to which it was applied. Rosin, a form of resin obtained from pines and conifers, was mostly used in this process. Often it was added to the pulp while it was being beaten ('engine-sizing'); sometimes the paper was dipped into a vat containing the size ('tub-sizing'), in the manner practiced since the 12th century. The three ingredients, fibre, filler and size, were then combined with water in beating engines, before the mixture was deposited in a thin layer over a belt of wire screen. The water would drain from the paper as the belt moved and the jarring motion of the screen compacted the fibres. The paper passed under a dandy roll which imprinted a watermark. It then moved from wire to felt belts which carried it past heated drying drums, before a final pressing between smooth calendar rollers. This faster process satisfied the ever-increasing demand for paper. It did not necessarily satisfy the bookbinder, some of whom considered these developments rather more like debasements which required the modification of traditional, well-honed skills.

Paper Grain

Machine-made paper has a grain. Unlike hand-made paper, where the fibres run in all directions, the fibres of machine-made paper tend to run in one direction only. Binders know that paper folds more readily with the grain running from head to tail of the book. Similarly, printers need to know which way a machine will fold the large sheets into sections; print and bind across the grain and you will soon know about it. Paper fibres continually expand and contract according to environmental conditions. This movement occurs significantly more across the grain direction of fibres than it does with the grain direction. So, when paper is bound into the spine across its grain direction, the glue and sewing at the folds will prevent the cross grain paper from stretching normally. This, in turn, causes problems for the whole book - boards will buckle, endpapers will crease or split and the sections may not lie down under their own weight, thus causing the entire textblock to cockle. Importantly for printers, reams of paper are usually labelled 'long grain' or 'short grain', indicating that the grain runs either along the length or width of a sheet. Folio and octavo books must always be made from sheets with a short grain, whilst quarto and sextodecimo books must be made from those with a long grain.

Determining the grain of a sheet of paper is quite simple. Place a single sheet on a flat surface and gently bring two opposing edges together without creasing it. Note the resistance of the fold. Then turn the sheet at right angles and gently attempt to fold again. The fold that offers the least resistance is the grain direction, and the direction in which the sheet must be folded.

Paper Sizes

Handmade paper can be created in any size. It depends solely on the size of the mould. Some of the most well-known sizes are:

- Crown (15 x 20 inches). A standard size paper watermarked with a regal crown.
- Elephant (23 x 28 inches). This paper also comes in Double Elephant and is used as a plate printing and drawing paper. Originally it was watermarked with a rudimentary figure of an elephant.
- Emperor (48 x 72 inches). One of the largest papers ever to be made in Europe
- Foolscap (approx. 13 x 17 inches). A printing and writing paper dating from the 1400s. It was named after its watermark which traditionally resembled a court jester wearing the distinctive bell-tipped, multi-pointed cap.

The Deckle Edge

Essai sur la conformite de la medecine des anciens... John Baker. 1749.
The original 'deckle' edge. Note that some of the pages also remain uncut.

The term ‘deckle’ refers to the narrow rim or fence which is placed inside the paper mould frame to prevent the wet fibrous mass from flowing over. The deckled effect occurs after the mould has been dipped into the vat of slurry and the excess water drained off. When the deckle is removed so that the sheet of paper can be couched (laid out), some of the matted slurry would pass under the deckle and form an irregular but thin edge. Before the 19th century this type of edge was unavoidable; the deckle simply couldn’t make a perfect seal against the mould frame. This meant that the binder would need to trim off the deckle edge as part of the binding process. In recent times the deckle-edge has made a comeback, with a number of books on machine-made paper now exhibiting the artificially produced edge.

Note: A deckle edge is completely unrelated to the ‘uncut’ or ‘unopened’ page edge which must be cut with a paper knife.

The First Text Printed on Paper

The world’s first text printing on paper occurred in approximately 770 A.D. Six years earlier, the Empress Shōtoku of Japan had sanctioned the printing of a million paper prayers (dhāraṇī) to drive out the demons of disease and evil spirits caused by a smallpox epidemic and to make penance for the loss of life that occurred in the suppression of the Emi Rebellion of 764 A.D. Over the years there has been some debate as to how the prayers where printed, whether by metal plates or woodblocks, but recent microscopic analysis has uncovered evidence of wood grain impressions suggesting that pigmented woodblocks were used after all.

The Hyakumantō dhāraṇī have long been considered the oldest extant examples of printing in the world but a recent discovery of a similar dhāraṇī in a stone pagoda in a Pulguksa Temple in Korea has lately cast doubt upon this. Some scholars believe it predates the Temple, completed in 751, but we wait to learn more. Stay tuned…

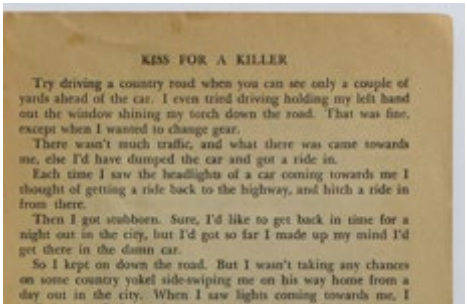
Papermaking in Australia

Papermaking in Australia had its origins among the convicts who were transported to Sydney, New South Wales. A number of these convicts gave their former occupation as papermaker, but it was John Hutchinson who had been a wool-stapler in England who made the first steps to establish a paper mill. In 1813 Governor Macquarie, having received many testimonials as to his abilities, gave him a conditional pardon and promised him land upon which to construct a woollen and paper manufactory. In March 1814 Hutchinson reported to Macquarie that he had conducted various experiments to remove inks and dyes from rags so as to make them suitable for the making of paper and had also identified a number of plants he believed to be suitable for use in the manufacture of paper. However, a short-lived partnership with Simeon Lord in 1813 resulted in Lord retaining possession of most of Hutchinson's equipment and records. Hutchinson also fell out of favour with Governor Macquarie who was concerned about his numerous requests for men and equipment while his experiments were not producing the sought-after results.

In 1818 the first mill known to have produced paper in Australia was established near Sydney, N.S.W. This was apparently run by three partners (Frederick George James Fisher, George Duncan and John Walker) who had raised capital by selling shares to about fifteen traders and officials (including Simeon Lord).

Adapted from 'Papermaking in Australasia to 1900', Alexander Romanov-Hughes http://home.vicnet.net.au/~paper/firstmills.html

Mechanical vs Chemical Wood Pulping



KISS FOR A KILLER

Try driving a country road when you can see only a couple of yards ahead of the car. I even tried driving holding my left hand out the window shining my torch down the road. That was fine, except when I wanted to change gear.

There wasn't much traffic, and what there was came towards me, else I'd have dumped the car and got a ride in.

Each time I saw the headlights of a car coming towards me I thought of getting a ride back to the highway, and hitch a ride in from there.

Then I got stubborn. Sure, I'd like to get back in time for a night out in the city, but I'd got so far I made up my mind I'd get there in the damn car.

So I kept on down the road. But I wasn't taking any chances on some country yokel side-swiping me on his way home from a day out in the city. When I saw lights coming towards me, I

Kiss for a killer. Stephen James. 1956
Visible browning of the mechanically pulped wood paper, a result of exposure to environmental factors such as moisture, heat, and light.

There is a significant difference between mechanically and chemically pulped wood paper. The pre-19th century method for cotton and linen rag paper production largely preserved the long fibres of the raw material. These fibres tended to remain strong and durable, especially when stored in optimum environmental conditions. When wood replaced rag in paper manufacture, those fibres were shortened. Mechanical pulping, in which the wood fibres are crushed and broken down by grinding in water, produces the shortest of fibres. It also fails to remove the lignin, the organic polymers in the cell walls of the plant which gives it its rigidity and which promote acid hydrolysis. Newspapers are the quintessential example of mechanically pulped wood paper. Left exposed to light, heat or moisture they will degrade in a matter of weeks, if not days. Chemical pulping, on the other hand, removes lignin

and it does not cut the fibres as thoroughly as in mechanical pulping, rather it separates them by the action of heat and alkalis. This produces a comparatively stronger paper but one that still falls short of the standard of rag paper.

Did You Know...?

You may hear it said from time to time that paper is not what it used to be, that modern paper disintegrates in a very short amount of time when exposed to light, humidity or changes in temperature. This statement usually finds its basis in the fact that the paper in books produced hundreds of years ago is still in excellent condition. In many ways this comparison is unjust. Early papermakers produced both fine and poor grades of paper. In fact, less expensive papers may have well suited the purpose for which they were intended. Over time, however, the inferior papers have perished entirely and what remains to preserve the papermakers' status is the finest of quality paper. The truth is that some (but certainly not all) papers that are produced today are likely as durable as their 500-year-old counterparts.

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