The Unwound Yarn
Birth and Development of Textile Tools Between Levant and Egypt
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1 The Ancient Fibres

1.1 Flax

Flax is a fibre extracted from *Linum usitatissimum* and it consists of 70% cellulose. Common flax belongs to the family Linaceae and descends from the Linum bienne (*Linum angustifolium*) plant (Baines 1989, 13-14), which grows naturally in coastal areas of the Mediterranean Sea and the Atlantic Ocean; it grows in the Mesopotamian area only in winter. It is a perennial plant, standing between 1.0 to 1.30 metres tall on a slender stem; it branches out at the topmost section of its stem and has lanceolate leaves and blue flowers. Several other species in the genus *Linum* are similar in appearance to *L. usitatissimum*, including some that have similar blue flowers, and others with pink, white or yellow flowers. Egyptian Old Kingdom tomb scenes generally depict flax fields covered with blue blossoms (Kemp, Vogelsang-Eastwood 2001, 25).

Flax fibres are extracted from the bast beneath the surface of the stem of the flax plant. They run from the root of the plant to the tip of its stem. An outer bark protects the bast, inside which the fibres occur in 'bundles' embedded within pectinous gums, waxes and non-cellulosic substances. Each stem contains between fifteen and thirty-five bundles (Baines 1989, 14), each containing between ten to forty individual fibres (Kemp, Vogelsang-Eastwood 2001, 25). Under magnification fibres show regular horizontal rings where their cells overlap. Flax fibres possess a natural 'S' twist, due to the positioning of microfibrils inside each fibre (Breniquet 2008, 83).

Flax was a highly exploited crop in antiquity due to its versatility: its seeds are edible and also provide oil suitable for consumption and lighting fuel), while the bast fibres were used for basketry and matting.[1] The extraction of flax fibres for spinning and weaving is a complex multiple-step process. It is not possible to obtain from one plant both seeds and

1 Recently, Breniquet (2008, 89) questioned this theory, suggesting that the domestication of flax occurred primarily for textile purposes and that the alimentary and medicinal uses of the plant were of secondary importance.

excellent fibres for weaving. If the flax was being grown for use in textiles, the seeds were sown close together so that stems grew tall but branches could not proliferate (Baines 1985, 3-4). On the contrary, if the plant was being cropped to provide seeds, it was sown with larger distances between individual plants, resulting in shorter plants, which expended more energy growing long branches.

Once the plant was fully grown, its stems were plucked out of the ground, not cut, to preserve the fibres at their maximum length. The highest quality of fibres was attained by harvesting flax when it was not completely ripe and still greenish. The strongest fibres were obtained from ripe half-yellow plants, while plants completely ripe (notable by their dark yellow colour) produced strong and highly-resistant fibres, desirable for weaving ropes and cords (Gleba 2008, 91). After harvesting the crop, stems were gathered in bundles, tied up and left to dry for about two weeks (Baines 1985, 4). Seeds were removed manually or with the help of a comb and the stems had to be retted[2] to free the fibres from the pectinous substance that bound them together.[3]

The retting operation could be conducted in soft-water streams or in pools over the course of ten to fifteen days,[4] otherwise it was possible to lay the flax out in thin layers on the grass (dew-retting), allowing natural humidity and dew to aid in the decomposition of the pectinous substance (Baines 1989, 15; Baines 1985, 4). If there was not enough dew, the flax needed to be manually watered to provide enough moisture. The process required continuous supervision of the fibres to prevent their weakening and destruction. It was possible to speed up the process using shallower pools, which are easily warmed by the sun, as decomposition is faster at higher water temperatures (Gleba 2008, 92). After retting, stems were dried again, hit with a mallet to break the wooden outer part and then 'scutched' to fully remove the stem casing; alternatively, this process could be accomplished by scraping fibres between two sticks held in one hand. Finally, the flax was 'hackled' with a series of combs (wooden or metal) to remove small remains of straw and to separate shorter fibres from the longer and better quality fibres.

Linen textiles have the advantage of being easy to clean and whiten, without requiring further chemical treatments; however, they are extremely difficult to dye, as colorants cannot penetrate deeply inside linen fibres,

2 It is the general method employed but it is not necessarily the one used in ancient Egypt or the Levant (Kemp, Vogelsang-Eastwood 2001, 30).

3 The process is represented on the walls of the tomb of Urarna in Sheikh Said dated to the Vth dynasty (Davies 1901, pl. 16), Zau in Deir el Gebrawi dated to the 12th dynasty (Davies 1902, pl. 6), and of Paheri at El Kab of the 18th dynasty (Tylor 1895, pls. 3-4).

4 Modern Sardinian flax workers, however, report that they used to leave the stems in water just for a couple of days.

so any colours applied fade quickly with laundering. In Ancient Egypt, textiles were generally bleached rather than dyed, but during the New Kingdom more coloured textiles began to be used.

The first archaeological evidence for linen fabric dates to the Pre-Pottery Neolithic B and comes from Naḥal Ḥemar Cave in Israel. From this context came also other examples of cords, basketry, fibres and fabric (Schick 1986, 96), some of vegetable fibres, some certainly of linen. These textiles date to between 6900-6300 BC and, notably, the linen examples were prepared, spun and plied to produce threads, but they were not woven: the fabric fragments preserved at Naḥal Ḥemar were created by looping and knotting strands into a type of netting (Shamir 2014, 147). Other caves in Israel such as Naḥal Mishmar and the 'Cave of the Warriors' have also provided evidence of Chalcolithic-period linen textiles.

Charred textiles made of vegetable fibres dating to the end of the seventh millennium were recovered from funerary contexts at the site of Çatal Höyük in Turkey (Helbaek 1963, 39-46; Ryder 1965, 175-6).[5] Even if fragmentary and burnt, they provide a great deal of information pertaining to the use of different techniques for producing fabrics, which involve both weaving and knotting netting.[6]

Flax was the first fibre to be used for producing textiles, later followed by wool. Both linen and wool continued to be used during the Bronze and Iron Ages, with wool predominating in the Levant and linen in Egypt. In Egypt flax does not occur in its wild form and it was likely introduced from Asia at an early date; remains of flax fibres are known in Egypt since at least the fifth millennium BC. In the Neolithic and Predynastic periods Egyptians appear to have experimented with all vegetable and animal fibres available to them, including reed, grass, papyrus, palm and esparto,[7] but the extensive cultivation and use of flax in the Pharaonic period reduced these others to a secondary role, for use in basketry, matting and cording, not proper textiles.

A similar process seems also to have occurred in Mesopotamia, where wool and linen represent the great majority of textual references to textiles. Wool is certainly the most common fibre and appears to have replaced flax as the principal fibre in Mesopotamia from the fourth millennium BC onward, although linen remained the cloth reserved for gods and kings (McCorriston 1997, 534). J. McCorriston, in her well-known article "The Fibre Revolution", analysed the social effects of the transition from flax cultivation to sheep breeding and linked it to the relationship between

5 For a reassessment of the matter see Breniquet 2008, 84.

6 Fibres were combed before spinning. They are z-twist and s-plied (Burnham 1965, 170).

7 Forbes 1956, 61-2; Lucas, Harris 1962, 134-5. More cautious is Vogelsang-Eastwood 2000, 269.

women and textile production from that moment onward. The introduction of wool certainly played a major role in the social organisation of urban Mesopotamia, but other factors might have contributed to create a textile industry that employed high numbers of female personnel, such as the possibility of paying them lower wages than male workers, and fewer difficulties in physically controlling them (especially if textile-working women were drawn from captured populations).

It should be emphasised that the situation of textile-creation in Mesopotamia was not necessarily mirrored in the Levant, where more differentiated patterns of labour organisation may have developed, and which may have also varied between the northern and southern Levant.

Also natural geography likely played a role, as Liverani commented in response to McCorriston's article (McCorriston 1997, 537). Liverani noted that the different choice of raw fibres for textile production in Mesopotamia and Egypt might not be due only to climatic necessity (i.e. warm wool clothing is required for at least part of the year in Mesopotamia), but also to the agricultural potential of the landscape. In fact, sheep breeding requires marginal lands not suitable for agriculture, which are widespread in the Near East but not in Egypt, centred on its highly productive floodplain. Furthermore, transhumant pastoralism fits perfectly into Mesopotamia's schedule of winter cereal crops, which leaves fields free for grazing sheep in summer, but is completely in contrast with the summer Nile flood.

1.2 Hemp

Hemp (*Cannabis sativa*) is another vegetable fibre important for textile production; it can grow three times as tall as flax plants and produces coarser fibres. It is usually employed to make ropes, sacks and sails rather than garments (Barber 1991, 15). Individual hemp fibres may measure between 1.5 and 3.5 m high and are extracted from the stem by means of a process very similar to that performed on flax. Furthermore, flax and hemp share a similar structure and it is not always easy to immediately recognise one from the other. In some cases, fibres from both plants were combined in order to strengthen yarn, and identifying secondary fibres requires sophisticated analysis (Murphy 2011, 2579).

Hemp was in use in the Levant from at least the Chalcolithic period as recent DNA analysis carried out on samples from the Christmas Cave in the West Bank have proved (Murphy 2011, 2580). The cave was used as refuge only in the Chalcolithic and Roman Periods. Among the numerous finds from the cave are woollen and linen textiles and ropes dating to the Chalcolithic period. One of the analysed textiles showed significant traces of hemp DNA as well as flax DNA, proving both the antiquity of the utilization of these fibres and the existence fibre-combining within single fabrics.

As of yet, there have been no specific studies on hemp cultivation nor on its use in ancient Egypt, but its history probably parallels that of flax, as hemp appears in certain Predynastic textiles (Tata 1986, 41). It is likely that a thorough study of the preserved Egyptian textiles and cordage result in an increase in the number of known cases in which it was employed.

1.3 Wool

Wool is a natural fibre that is obtained from sheep and some types of goats, rabbits, camelids and llamas. With a microscopic analysis it can be noticed that, longitudinally, wool fibres have small scales covering their outer surfaces, while in section it is circular. Wool fibres are made up of a protein substance, keratin, and a fatty substance, lanolin. They measure between 2 and 90 mm in length and possess numerous elastic ripples, which is the origin of the typical crimp. This structure gives the wool softness, elasticity, hygroscopicity and highly thermal insulation.

Wool is removed from the animal through plucking, shearing or cutting off the animal's coat. Plucking is likely the oldest method, since efficient shearing requires iron scissors, which did not come into use until the first millennium BC;[8] shearing can also be done with the aid of a knife, although the result is less uniform than with the use of scissors. However, both shearing and cutting provide the potential for two wool-harvests per year (Andersson Strand 2010, 11). Plucking, conversely, occurs during the animal's natural moulting season, a period when the rougher fibres are not present in the fleece, allowing easier selection of the softest fibres. The plucking process, however, is more time-consuming and can be done only once a year.

The fineness (or diameter of individual fibres) is the most important element for assessing the quality of wool and, such as the length of each fibre, depends on the part of the animal from which it is harvested (from the hips, belly, shoulder area, etc.). The quality of a fabric mostly depends on how carefully the fibres are selected and prepared. Criteria for the fibre selection process may be colour, fineness, length, strength, crimp or texture. These qualities are mostly contingent upon the animal's sex, health and age (Gleba 2008, 98). Sheep fleece has three qualities of fibre: underwool, which is the finest part of the fleece, hair, which is the easiest type to spin, especially if mixed with finer underwool, and finally the rough fibre, called 'kemp,' which is thicker and more difficult to spin on its own

8 The first clear evidence for the use of scissors in the ancient Near East comes from a Neo-Babylonian text (Forbes 1956, 8). Breniquet believes that the introduction of clipping with scissors can be traced back to at least the 2nd millennium, based on the few mentions of sheep being washed (Breniquet 2008, 107-8).

(Peyronel 2004, 40; Barber 1991, 21). In the past, sheep fleece was different from that of today's sheep, because composition of modern fleece is the result of a long genetic selection process. Primitive sheep' fleece had a mix of the three types of fibres and higher percentages of kemp (Barber 1991, 22) than nowadays fleeces.[9]

Although wool can be spun immediately after being removed from an animal, it is usually first combed and carded. Carding and combing enable impurities to be released, fibres to be disentangled and re-aligned in parallel, which in turn allows for the subsequent spinning operation. Carding pushes air into the fibres, which is useful for the production of stronger threads (Gleba 2008, 98). In some cases, wool can be spun without having been washed, because lanolin might aid the spinning process. However, it is usually washed before spinning both to remove impurities, which can represent up to 40% of the total weight of the wool, and if it must be dyed before the spinning process. Wool is a much more elastic fibre than linen and from this arises some technical issues in the weaving process (Barber 1991, 21). Furthermore, unlike linen, wool dyes thoroughly and easily, and is also naturally available in different colours.

The earliest use of wool as a textile material is still debated; while it is clear that it must be a result of the domestication of sheep, which occurred during the Neolithic age, it is not possible to distinguish between the remains of sheep used for food purposes or those used for textile production (Barber 1991, 22; Breniquet, Michel 2014, 4). In theory, the presence of castrated rams within particular flocks would suggest that those herds were bred for the wool production, since they did not produce milk and the best wool derived from their fleece. Unfortunately, the quantity and state of preservation of sheep bones from the Neolithic does not permit such detailed observations (Barber 1991, 26).

The first wool fabric found in archaeological contexts is seen in Egypt and dates to the fourth millennium BC (Petrie, Quibell 1896, 24), replacing the previous identification of Çatal Höyük as the site from which the earliest wool samples come (Ryder 1965, 175-6; Barber 1991, 25).[10] Wool certainly had a long history of use in Egypt, as early dynastic finds from Naqada and Helwan prove (Saad 1951, 44), as well as some fragments from the Amarna workmen's village dating to the New Kingdom (Vogelsang-Eastwood 2000, 269). Wool, as it is described by Herodotus (Book 2, 82), was considered impure by the ancient Egyptians, but this prescription probably concerned mainly the priestly classes and funerary contexts, but

9 For an archaeometric and evolutionary study on some textile samples see Gleba 2012, 3660.

10 Ryder, as a matter of fact, definitely excluded that textiles from Çatal Höyük were made of wool, as it was previously claimed. However, certain of these fibres show typical wool scales, although it is not possible to determine which kind of animal they come from (Peyronel 2004, 36 fn. 13); of the same opinion is Breniquet (2014, 57).

not the common sphere of everyday life (Forbes 1956, 5). However, wool findings in Egypt are extremely rare for the whole Pharaonic period.

In the Near East, wool seems to have been in wide use from the late Chalcolithic period onward. At Arslantepe (Frangipane et al. 2009, 12), a decisive increase in the percentage of sheep and goat bones within the animal bone assemblage was noted, as was a change in the diameter of spindle-whorls in the IV a-b period, which might together indicate the adoption of wool as the main textile fibre at this site. Aside from sheep's wool, it seems that goat hair was also used, as suggested by the discovery of a mineralised textile from Arslantepe phase VIb, dating to the beginning of the third millennium (Frangipane et al. 2009, 19-20). Despite the fact that few traces of woollen fabrics survive from ancient Near Eastern contexts, due to the climate and the chemical composition of the soil, texts have provided a description of the intensive exploitation of wool in Mesopotamia, Syria and parts of Anatolia, beginning in the fourth millennium and increasing in the third and second millenniums.[11]

1.4 Silk

Silk is a natural protein fibre secreted by certain insects of the Lepidoptera order and by some types of spiders. However, the silk used for textiles is generally obtained from the *Bombyx mori* species. It is extracted from the cocoon of this insect, which is made up of an extremely fine bave, a substance that solidifies in contact with air and produces silk filaments, which vary in length between 300 and 900 m. These insects, commonly known as 'silkworms,' must be reared in captivity in order for their developmental stages to be controlled. If their metamorphosis is allowed to be completed (the worm transformed into a moth), the adult insect will break the cocoon to exit, damaging the filaments from which it is made (Barber 1991, 31). The cocoon is therefore collected and boiled before the insect reaches maturity, both to kill the worm inside and to dissolve an additional layer of sericin protein, which acts as a glue holding the filaments together. The first evidence for silk cultivation comes from China and dates to the Neolithic period: it consists of a cocoon of the *Bombyx mori* species that was artificially cut, but actual silk textiles are documented only from the onset of the Early Bronze Age (Barber 1991, 31).

The archaeological record cannot provide much comment on the beginnings of silk production in the ancient Near East and Egypt, as the creation of silk as a textile does not require tools different from those used for wool

11 For a general presentation see Breniquet, Michel (2014, 6-7). For reference about textual sources see Waetzold (1972), for Ebla (Pasquali 1997), for Mari (Durand 2009) and for Ugarit (Matoian, Vita 2009).

or flax. Until recently, silk was known in Greece and Western Europe from only the second half of the fifth century BC, and these fibres were probably extracted from wild species of insects, native to the Mediterranean area (Peyronel 2004, 40). Outside of China, the other earliest archaeological evidence of silk fabric also dates to the fifth century BC and comes from a kurgan tomb in Pazyryk, in the Altay Mountains; this fragment, however, is of Chinese origin.

In recent excavations at the House of the Ladies at Akrotiri a silk cocoon was recovered from a level of LM IA (Van Damme 2012, 166), which suggests the utilization of this resource long before previously thought. As previously mentioned, silk textiles in the Mediterranean area are known from mid-first millennium, but appear in Egypt only after the 5th century AD (Rutschowskaya 1990, 25). It might seem strange, given the huge amount of textiles preserved in that country, but Egypt was a rather closed country in antiquity; it is possible that silk circulated in the Mediterranean without reaching the Egyptian market. The textual, iconographical, and now even archaeological hints at the ancient exploitation of silk make potential future finds of the remains of silk cultivation or textiles from the Bronze and Iron Ages less incredible than they once were.

1.5 Cotton

Cotton is obtained from hairs that cover the seeds of plants of the genus *Gossypium* (family *Malvaceae*). It is a species that appears to be native to India, where cotton fibres dating back to 2500 BC have been found at both Mohenjo Daro and Harappa (Forbes 1956, 43-5; Peyronel 2004, 33-4). In the Near East the first attestation of cotton is generally considered a royal inscription of Sennacherib (705-681 BC) who is quoted stating that he planted gardens in Nineveh with “trees bearing wool” (Forbes 1956, 45; Oppenheim 1967, 245). However, cotton was known and used before that date since it was found in some garments of the Assryian Queens’ Tombs at Nimrud, dating to the 8th century, and probably arrived from Babylonia.[12]

In ancient Egypt cotton is not attested until the 1st century AD (Vogelsang, Eastwood 2000, 268), although species of cotton plants are also native to Nubia. Cotton fibres are known from the site of Dhuweila in Jordan, and they have been carbon-dated to the final Chalcolithic period or the beginning of the Early Bronze Age (Betts 1994, 493), preceding the first evidence from India and slightly also those from Nubia. Since cotton is not native to Jordan, it has to be arrived either from Nubia or from India, but today the regional provenience of these fibres is still unknown.

12 For an analysis of the term used see Gaspa 2017, 157-8.

Preparing cotton for spinning is very simple, since it only requires the 'ginning' process that separates the fibres from the seeds and removes other impurities. Similarly, the spinning of cotton fibres is notable for requiring extremely light whorls, often made of shell or vitreous paste, because otherwise the short and thin cotton fibres would break.

1.6 Other fibres

Nettle fibres (in particular *Urtica dioica*) can be used for the production of textiles, although in East Asia the species 'ramia' is mainly used (*Boehmeria ramia* and *Boehmeria viridis*) (Peyronel 2004, 32). The woody stems of mature plants were soaked, dehydrated and beaten, resulting in fibres that can be separated by hand and woven into fabrics similar to those produced from hemp or linen. Recent discoveries and archaeometric studies have shown that, at least in Europe, nettle was used more broadly than was thought until a few years ago. These discoveries also questioned the generally accepted concept, derived from textual sources, of the cessation of wild-plant exploitation for textile production, in favour of linen and wool cultivation.

The earliest physical evidence of nettle, dating to the Mycenaean period, is found within a textile made of several other fibres: warp made from a vegetable fibre, probably flax; the weft made from an animal fibre, likely goat hair; and a third type of thread, sewed in the band, has been identified as nettle (Moulherat, Spantidaki 2009, 8-15). A second piece of evidence for the use of nettle comes from Denmark and dates to the late Bronze Age, between 900 and 700 BC (Bergfjord 2012, 2). It was identified by means of a new methodology. Nettle fibres (like flax) have a natural 'S twist', while hemp fibres have a natural 'Z twist'; moreover, hemp and nettle contain calcium oxalate crystals, while flax does not. The fabric showed calcium oxalate crystals under microscopic examination and the orientation of the fibrils corresponded to an S-twist, therefore proving its identification as nettle.

Esparto grass is obtained from *Ligeum spartum L.*, a perennial plant typical of the Mediterranean; it is rich in durable and tenacious fibres and is thus used mainly for mats, rugs, cordage, baskets and fishing nets. Esparto was known in Mesopotamia and used by the ancient Egyptians for rope production (Peyronel 2004, 33), but there is no evidence regarding its cultivation.

Finally, certain molluscs of the *Pinna nobilis* family produce 'byssus' silk or 'marine silk'. In the mollusk's foot there is a gland that secretes a semifluid substance, which solidifies upon contact with water and forms a bundle of filaments used by the animal to fasten to a support. The byssus fibre of the *Pinna nobilis* can be woven into a soft, silky fabric of a natural golden brown colour with greenish hues.[13] Silk of a marine origin seems to have been known in the Near East since at least the 1st millennium BC, although its use could be much older.[14] The difficulties in its preparation combined with its scarcity and the high-quality of its finished fibres made this fabric the reserve of privileged groups.

13 This is the description of fibre preparation given by the last Italian byssus weaver, Chiara Vigo: "Silk needs to be desalted for a period of 25 days, taking care to change fresh water repeatedly until complete desalination. The fibre is then drained in shadow until it is perfectly dry. It is immersed in a bath made of various natural elements, which make it elastic and ready to be woven. After this treatment it is lustrous, and has a beautiful amber colour. The fibre is dried in a ventilated and shady place so to not dehydrate too much. For carding, a very small card with pins is used to separate the fibres from any tiny algae still present. For spinning, it is essential to use a small spindle with a head not exceeding 3.5 cm in diameter and with a rod no longer than 20 cm. Spinning is very complex since it must concatenate fibres no longer than 2 or 3 cm. The weaving of textiles made with nails [...] runs on linen warps and the beating can only occur with the use of cane reeds" (Authors's translation).

14 Breniquet proposes identification with the term *busu* in Akkadian (2008, 101).