Canadian Conservation Institute
Institut canadien de conservation

CCI Notes 13/11

Natural Fibres

Introduction

Museum staff who care for textiles should have a basic understanding of the characteristics of fibres.

This Note provides an introduction to four natural fibres: cotton, flax, silk, and wool. Cotton and flax are vegetable fibres composed of cellulose. Silk and wool are protein fibres that are made up of various amino acids.

A burn test can provide basic information on fibre group, i.e. cellulose or protein, but a good light microscope is required to make a more definitive identification of a fibre.

Cellulose Fibres

Cellulose fibres are found in stems, leaves, and seed bolls of plants. Many varieties of plant fibre have been used throughout history. Hemp, jute, ramie, sisal, and coir are regularly used in various parts of the world. Cotton and flax are the most common vegetable fibres found in Western museum collections. Table 1 lists some of the properties of undegraded cellulose fibres. However, the characteristics of cellulose are altered by ageing and degradation, which is manifested in many different ways; for example, fibres are more vulnerable to light, and can weaken and change colour.

Cotton

Origin
Cotton fibres come from the seed heads or bolls of the cotton plant (genus *Gossypium*), a member of the Malvaceae or mallow family. The quality of cotton depends on the variety and the climatic conditions under which it is grown.

Physical characteristics
Cotton fibres are almost pure cellulose and are between 1 and 6 cm long. A cotton fibre consists of an outer cuticle, a primary and secondary wall (the bulk of the fibre), and a central core or lumen (Figure 1). Mature cotton fibres have thick walls and a small, discontinuous lumen. Mercerization (a process using caustic soda and tension) causes the fibre to swell, straighten, and become more cylindrical, thus promoting lustre, dyeability, and increased strength.

Figure 1. a, Cotton fibre, longitudinal view; b, cross section of cotton fibre showing central lumen.

Flax

Origin
Flax is a fibre obtained from the stem of the plant *Linum usitatissimum*. A considerable amount of processing is required to extract the useful fibre from the rest of the stem. After it is processed into threads and fabrics, it is called linen. The quality of flax depends on the growing conditions, the age of the plant, and fibre processing.

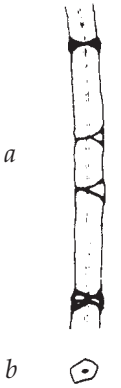

Figure 2. a, Flax fibre, longitudinal view; b, cross section of flax fibre showing central lumen.

Physical characteristics
Though high in cellulose content, flax is not as pure a fibre as cotton and contains lignin, pectin, fat, and wax. Its fibre length can reach over 30 cm. The main parts of a flax fibre are the outer layer, fibre bundles or fibrils (the bulk of the fibre), and a central lumen (Figure 2).

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Table 1. Properties of undegraded cellulose fibres

	Strength	Absorbency	Elasticity	Fabric handle	Resistance to acids and bases	Resistance to light	Resistance to mould and bacteria	Resistance to insects
Cotton fibres	• strong • stronger when wet	• good absorbency	• fairly inelastic	• conducts heat so feels cool to the touch	• weak acids damage cotton and flax • strong acids destroy cellulosics • alkalis, like those present in detergents, do not damage cotton and flax	• will turn yellow when exposed to sunlight, and more severe degradation will occur with prolonged exposure; this process can be accentuated by heat, moisture, and certain dyes	• in the presence of warmth, high humidity, and dirty conditions, mildew, a type of fungus, and some bacteria can cause odours, stains, and decay	• the larvae of clothes moths and carpet beetles will not attack clean cellulose fibres, but dirt on textiles serves as a food source for most insects, and can result in damage • silverfish will eat cotton and flax if the fabric is starched
Flax fibres	• very strong • stronger when wet	• very good absorbency • absorbed moisture evaporates quickly	• poor elasticity • tends to crease			• good resistance to light, but degradation will occur with prolonged exposure		

Other causes of cellulose deterioration

- Wetting and slow drying of cellulosic textiles will cause a characteristic brown line staining, which is an area of weakness.
- Cotton and linen textiles tend to retain creases and folds. These areas may become brittle with time, requiring care in handling and storage.
- Manufacturing and finishing processes such as bleaching and dyeing may weaken cotton and linen fabrics.

Protein Fibres

Protein fibres are animal in origin. These multicellular fibres are obtained from coats of mammals or are secreted by larvae of insects such as the silkworm. Hair from indigenous species of animals has been used worldwide to make textiles and garments. It can be spun into yarn, or converted directly into a non-woven textile by felting. There are many varieties of protein fibres. Silk and sheep's wool are the most common animal fibres in most parts of the world. Table 2 lists some of the properties of undegraded protein fibres. However, these properties are altered by ageing and deterioration.

Silk

Origin

Silk is a continuous protein filament produced by the silkworm when forming its cocoon. The principal species is *Bombyx mori* (cultivated silk). Tussah silk (produced by *Antherea mylitta* and *Antherea pernyi* moths) is darker in colour and is sometimes referred to as uncultivated or wild silk.

Physical characteristics

Silk fibres can be more than 2 km long. Unprocessed silk consists of two fibres of the protein "fibroin" held together with a soluble silk gum called "sericin". Sericin accounts for 10–20% of the weight of silk. Once the sericin is removed, silk separates into two filaments (Figure 3).

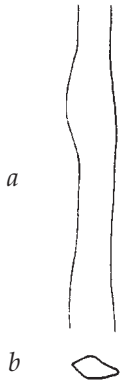

Figure 3. a, Silk fibre, longitudinal view; b, cross section of silk fibre.

Table 2. Properties of undegraded protein fibres

	Strength	Absorbency	Elasticity	Fabric handle	Resistance to acids and bases	Resistance to light	Resistance to mould and bacteria	Resistance to insects
Silk fibres	• very strong	• very good absorbency	• good elasticity	• does not conduct heat so feels warm to the touch	• damaged by mineral acids (sulphuric, nitric, hydrochloric, hydrofluoric acids) and strong alkalis (sodium hydroxide, sodium hypochlorite) • organic acids and weak alkalis have little effect	• exposure to sunlight causes silk and wool to yellow and degrade • silk is particularly sensitive to ultraviolet radiation	• good resistance to microorganisms	• can be destroyed by carpet beetle larvae
Wool fibres	• weak • weaker when wet		• very good elasticity		• good resistance to dilute acids • damaged by weak alkalis such as soap • destroyed by concentrated acids and alkalis		• mildew will grow if stored in damp conditions	• attracts the larvae of clothes moths and carpet beetles, especially if it is soiled

Wool

Origin

Wool is a protein fibre forming the protective coat of sheep. There are over 200 grades of sheep that produce varying qualities of wool. Merino is the finest quality of wool.

The fleece from some other animals is also used, e.g. the Angora goat (mohair), the Cashmere goat, the Angora rabbit, and members of the Camelidae family (alpaca, llama, vicuna, and camel).

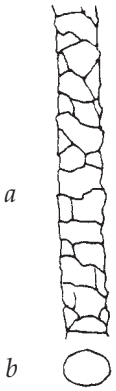

Figure 4. a, Wool fibre, longitudinal view showing outer scales; b, cross section of wool fibre.

Physical characteristics

Wool fibres are sorted into various lengths for processing. Typically wool fibres are between 4 and 15 cm long, but can be as long as 38 cm. Sheep's wool consists mostly of keratinous proteins; all mammalian hair and wool fibres are similar in this respect. A wool fibre consists of a cuticle or outer layer that includes scales characteristic of the wool fibre; a cortex, which is the bulk of the fibre substance; and a medulla, the hollow central canal that may be lacking in very fine and immature fibres (Figure 4). The outer scales are important for fibre identification, and for making felt, a non-woven fabric. Often the scale pattern is altered or destroyed in very degraded fibres.

Other causes of protein fibre deterioration

- Deterioration of silk is accelerated by heat and moisture. When wool fibres are subjected to heat, moisture, and friction, the overlapping scales will interlock and cause irreversible matting and shrinkage (i.e. felting). Felting is considered to be a form of damage to wool fabrics if it occurs accidentally.
- Weighted silk is treated with metallic salts such as tin chloride. This process is used to compensate

for the weight lost when sericin gum is removed before dyeing, and to give added body to the fabric. Weighted silk is more vulnerable to accelerated deterioration from light and air pollutants than unweighted silk. Similar deterioration can occur when silk is mordanted with metallic salts in the dyeing process.
- Both wool and silk are particularly vulnerable to damage by chlorine.

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