MA Britta Schwenck

Identification of fibres and fabrics

1	Title: Identification of Fibres and Fabrics
2	**Introduction** The lecture contains the following points: fibres, fabrics and techniques and in the end some examples of textile objects. Fibre identification is one of the first steps in conservation of textiles. If you know the fibre (the material), you can choose the right conservation treatment or best way to store or display a textile. Simple methods for identifying fibres are the burn test and microscopy identification (identify cotton, flax (linen), wool and silk or synthetic fibres). Knowledge of the technique of fabrics helps to understand the textile and the condition of the textile.
3	**Classification of textile fibres** Natural, mineral, metal and synthetic fibres Natural fibres come from animal, vegetable and mineral sources. In general terms these groups encompass protein, cellulosic and glass or asbestos materials. Natural fibres are for example the bast fibres, like flax and hemp, the leaf fibres, like sisal, the fruit fibres, like cotton and the animal fibres like wool and silk. Asbestos and glass belong to the mineral fibres. The synthetic fibres can be divided in regenerated cellulosic and synthetic fibres. Regenerated fibres are made of cellulose (e.g. viscose) and the synthetic fibres are made of mineral oil (e.g. polyester).
4	**Structure of fibres** A fibre is defined as a unit of matter with a length at least 100 times its diameter, a structure of long chain molecules having a definite preferred orientation, a diameter of 10-200 microns and flexibility.) The size number of side-chains linking to the molecule and the presence of crystalline an amorphous areas influence the properties of mechanical strength, flexibility and water absorptions. In the chemical composition the presence of polar groups affect the ability to dye the fibre, which is important for dyeing conservation materials. Fibres are built up of polymers (Molecules of many repeating units). Fibrils: orientated chain of cross-linked molecules. Molecules → fibrils → cuticle
5	**Cellulosic fibres – structure of cellulose** simply constructed, consist of the polymer cellulose built up from cellobiose units. The pairs of cellulose rings are joined together in a long-chain molecule linked by valency bonds. The chains can be very long but are flexible and very strong. Long chains of glucose molecules $(C_6H_{10}O_5)_n$. Examples for cellulosic fibres (cotton, flax, hemp, viscose etc.)
6	**Cotton** Cotton is made of natural cellulose, it is a seed hairof Gossypium herbaceum, Gossypium hirsutuin. The cell wall has three layers. The cuticle, which covers the outside, the primary wall, consisting of three layers of fibrils each at a different angle to the axis, and the secondary wall laid down after the cell is fully grown. The central lumen is hollow. As The fibre dries out the walls collapse and twist, producing the characteristic shape in cross-section and longitudinally. 85% cellulose, cuticle made of waxes and peptic material.

7	**Cotton** The single fibres are hollow and have a tapering cell. The length is 12-55mm, the diameter: 15-20 µm. The cross section shows an ear shaped fibre with a large lumen (the central hollow tube) and a thin wall. The longitudinal form is twisted, with frequent changes of direction. The colour of the cotton fibres is light brown, the lustre is low. High crystallinity (approximately 75%), some amorphous areas, cotton fibres are strongly polar with many OH-groups. They are not easy to dye.
8	**Flax (Linen)** Bast stem fibres of linum usitatissimum. The fibres are a bundle of thick walled cells, numbering 12-40 in each bundle, only rarely broken down to single units, called ultimates. The cell wall has three layers. The inner and outer layers have fibrils in a Z-twist and the thick middle layer an S-twist. The wall is thick and the lumen small, the end of the walls overlapping to form a continuous tube. 60% cellulose, rest lignin, hemicellulose , pectin, waxes etc.
9	**Flax (Linen)** Length 150-1000 mm (ultimates: 5-65 mm), Diameter: approximately 25 µm Cross section shows a bundle of polygonal cells with a small lumen and thick walls. Longitudinal Form: unlike cotton the fibres are straight but bear transverse X shaped dislocations at points along the length. The colour of the linen fibres is cream and beige, the lustre is medium. Highly crystalline, fibres are strongly polar with many OH-groups, not easy to dye.
10	**Hemp** Hemp is also a bast stem fibre of cannabis sativa The properties of hemps are similar to flay, but the fibre is stronger and more durable. The fibres are a bundle of thick walled cells, numbering 12-40 in each bundle, only rarely broken down to single units, called ultimates.
11	**Hemp** Length 80-3000 mm (ultimates: 5-55 mm), Diameter: approximately 15-50 µm Cross section shows a bundle of polygonal cells with a small lumen and thick walls. Longitudinal Form: unlike cotton the fibres are straight but bear transverse X shaped dislocations at points along the length. The colour of the linen fibres is beige (darker than flax), the lustre is medium (less than flax). Highly crystalline, fibres are strongly polar with many OH-groups, not easy to dye.
12	**Kapok** Seedfibres of *Ceiba pentandra*. Colour: white, beige, lustre: high Soft, but inflexible, too brittle to spin, does not waterlog)
13	**Jute**

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	Bast fibre, from the inner bark of plants of the genus *Corchorus* Bundles of individual fibres held together by gummy materials. 20% lignin. Colour: yellow to brown to dirty grey, lustre: silky Characteristic smell.
14	**Ramie** Bast fibre, from *Boehmeria nivea* or *Boehmeria tenacissema* (stingless nettles) Colour: white, lustre: high Similar properties to flax, high tensile strength
15	**Sisal** Leaf fibre from the plant *Agave sisalana* Colour: white, lustre. High High tensile strength
16	**Manila** Leaf fibres from plants of the *Musaceae* family Colour: depends on quality (from white to black), lustre. High Tensile strength similar to flax
17	**Coir (cocos nucifera)** Coarse fibre from the husks of coconuts (*cocos nucifera*). Colour: dark brown, lustre: low
18	**Protein fibres** Built up from amino acid units into polypeptides which link together to form protein. Basic formula: CHR (NH_2).COOH. There are around 20 commonly occurring amino acids
19	**Wool** Wool fibres are body hair from sheep. Other animal hair from goats, camels, rabbits etc. have similar structure and behaviour. Wool fibres are single usually solid, tapered multi-cellular fibres, but sometimes containing hollow tube depending on the part of the animal from which it was taken. Each fibre is formed by the multiplication of cells at the base of the follicle. The fibre has a central cortex of spindle shaped fibrils surrounded by a cuticle of scales, each of which is a cell. Wool protein is called keratin, made up from amino acid, which have a disordered helical structure with a high proportion of long side chains. Varying quantities of lanolin (greasy wax-like material).
20	**Wool** Length: 90-250 mm (noils: 12,5-100mm), diameter: 19-40 µm. Cross section: circular to oval, Longitudinal form: crimped with variable amplitude tapering to a point (scales). Colour: creamy white, beige, brown, or black, lustre: variable. Low crystallinity, polar, groups include OH-, NH3+ and COO-, easy to dye due to presence of acidic and basic qualities.

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21	**Angora** Hair from angora rabbit, fine, soft, light, good water absorption
22	**Mohair** Hair from angora or mohair goat Length: up to 30 cm, fine fibres, soft, light crimp, Colour: white, cream, lustre: high
23	**Cashmere** Hair from cashmere goat Long fibres, fine, soft and smooth, colour: white, creamy, lustre: high, most expensive natural fibre
24	**Alpaka, Lama, Vicunja, Guanako** Hair of different types of lama South America) **F**ine, soft, lightly curled, lustre: high
25	**Camel** Hair of (Bactrian) camel Very fine, soft, lightly curled, colour: beige, young camels: more creamy-white
26	**Silk (cultivated)** Silk is a protein fibre, made by the Silk worm (e.g. Bomby mori), Tussah from Antheraea myltta (India) and Antheraea perin (China). Double filament extruded through the head of the silkworm. Fibrils are laid parallel to the axis of the filament. The main constituents are the proteins fibroin and sericin, which are made up from the same amino acids as wool, but glycine, alanine, serine and tyrosine predominate. These have short side chains, enabling the molecules to lie close together.
27	**Silk** Length: 2700-3600mm, Diameter: 28-36 µm Cross section: two triangular shaped filaments (brins) gummed together across the base of the triangles to form a base. Longitudinal form: filament without surface features. Colour creamy white, lustre: high Highly crystalline, polar, various groups including OH-, NH3- and COO- Moderately easy to dye due to the possession of the acidic and basic qualities.
28	**Asbestos** Mineral fibres. Occurs in fibrous forms, withstands high temperature, flexible and resistant to chemicals.
29	**Metal Threads** There are different ways to produce metal threads. Mostly the metal threads are wrapped around a soul (silk or linen thread). The flattened metal wire (gold, silver, gilded silver or copper) is mostly wrapped around a silk thread Cuticle gold was used in the middle ages in Europe. A membrane (from pigs) was gilded and then

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	wrapped around a linen or silk thread. Gilded leather strips came later on, in Asia (China and Japan) they used gilded paper.
30	**Metal threads** Can be found in woven textiles and embroidery (examples of the different types of metal threads)
31	**Synthetic fibres** Made from natural polymers (e.g. cellulose) or synthetic polymers (e.g. petroleum). Different types: polymerization, polycondensation, polyaddition.
32	**Cellulosic fibres (Viscose)** Made from natural materials, first dissolved and then extruded as filaments which can be spun together. Homogenous filament. Cellulose, hydrolysed so that the polymer chains are only about one-quarter the length of the originals and in which substituents have replaced not more than 15% of the hydrogens of the hydroxyl group. Man-made, regenerated cellulose, source: an acid an amine, made by combining diacids and diamines Single filament Length, diameter: regulated in manufacture, continuous filament or short lengths for spinning, cross-section: irregular, jig-saw-puzzle shape Longitudinal form: can be given crimp in manufacture. Colour: white, lustre can be varied Crystallinity: variable, polarity abundant OH- groups
33	**Synthetic Fibres** Most important fall into the classes of polyamides and polyester
34	**Synthetic fibres** Different types of reactions/production Polymerization (same monomers without substitute) , Polycondensation (different monomers with substitute), Polyaddition (different monomers without substitues)
35	**Polyamide Nylon** Polyamide (Nylon) Produced by condensation polymerization of diamines and diacids, chemically related to the natural protein fibres. Most important Nylon 6.6 Man-made synthetic polymer Single filament, length, diameter, cross-section, longitudinal form: variable in manufacture according to the requirements of end product, lustre: variable High crystallinity, non-polar, easy to dye
36	**Polyester** Are based on polyethylene terephthalate and are produced in a similar manner to nylon. Man-made synthetic polymer, source: Therephthalic acid and ethylene glycol. Single filament, length, diameter, longitudinal form: variable, cross-section: round, but variable

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	Colour and lustre: variable High crystallinity, non-polar
37	**Identification of fibres** Identification of fibres For identifying the fibres there are different methods. The first and simple method is the burn test. If you take a sample of the fibre and burn it, you can identify the fibre because of the smell and the ash. Samples of the fibre can be also identified under the microscope. The structures (longitudinal form) of the fibre show some characteristics. Chemical tests can also help to identify the fibre.
38	**Burn test** A simple method to identify fibres is the burn test. Take a small sample of the fibre and burn it. See how the fibre burns or melts, smell carefully. Take a look at the ash Cellulose smells like burned paper Protein smells like burned hair Synthetics are melting.
39	**Microscope** Microscope pictures showing cotton, flax, wool and silk fibres. Cotton: looks like a ribbon with twists (convolutions) along the length of the fibre Flax: single fibres (ultimates) have nodes at intervals along the fibre length, irregular width. Often a bundle of fibres tightly packed in the lengthwise direction, rather than individual fibres. Wool: outer surface and edges rough, due to overlapping surface scales. Animal hair show different surface. Silk: looks like cylindrical, smooth rod with periodic bulges.
40	**Micro-chemical tests** Put the Fibre on a slide, one drop of chlorzinciod (zinc chloride and potassium iodide). The fibres will change their colour. Cellulose: colour changes to violet, lignified parts: colour changes to blue or violet.
41	**Solubility of synthetic fibres** The identification of synthetic fibres is more complicated, because they often look similar. It is possible to identify them by their solubility in solvents: 1 Acetic acid 2 Concentrated Hydrochloric Acid 3 Cuprammoniumhydroxide The most resistant fibre is Polyester.
42	**Threads and yarns** In the process of spinning, the fibres are drawn out from a bulk supply and rotated at high speed, twisting them to form a continuous thread or yarn. Twist can be S or Z direction. Several threads can be twisted together to form bulkier and stronger threads.

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43	**Classification of Fabrics** After spinning the threads, different types of fabrics can be made. One of the most important groups of textiles are woven fabrics. The other group is non-woven textiles, These includes the techniques like knitting, braiding and lots more.
44	**Weaving** Means crossing threads above and below one another. In order to make cloth a set of threads is laid parallel to each other, held under tension on a loom. The warp is vertical, the weft horizontal. The whole set of threads is the warp, running through the complete length of the piece of cloth. Another thread is wound upon a shuttle which is passed under and over the alternate ends across the whole part of the warp, reversing the order in the return direction.
45	**Different types of looms** Warp weighted loom: since bronze age Draw loom: for fabrics with more thread systems, two persons were needed for weaving, complicate patterns. Jacquard loom: invented in the 19^{th} century, for pattern-weaving. Every warp can be handled on its own.
46	**Foot-treadle floor Loom,** Showing the principle of weaving. most common loom today
47	**Weave Structures** Three weave structures: tabby weave, twill weave and satin weave.
48	**Tabby weave** or plain weave is the simplest technique. It is always one up and one down in both directions. It produces a uniform surface back and front. In **tapestry weave** the picks do not pass through the whole length of the shed but are passed back and forth in blocks of colour to form a pattern.
49	**Twill** weaves give a diagonal effect. The weft threads are passed over one or more warp threads and then under two or more warp threads and so on, with a "step" or offset between rows to create the characteristic diagonal pattern. As you can see in the picture above, there are two directions: the S- and the Z-direction. A famous twill fabric is jeans.
50	In **satin** weave a similar binding system is used as for a twill, except that the unit is at least five. No regular pattern. No binding points (space between them) Satin fabrics have a glossy surface.
51	**Tapestry** In a tapestry weave the picks do not pass through the whole length of the shed but are passed back and forth in blocks of colour to form a pattern.

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52	**Fabrics with three thread systems** Velvet 3-dimensional fabric, mostly woven in tabby weave, but has a second weft thread. This thread is laid in loops which are cut after weaving. In former times it was made of silk, today it is often made of cotton.
53	**Fabrics with three or more thread systems** Taqueté. Special weaving technique, Tabby weft composite weave Fabric with two or three wefts and two warps.
54	**Fabrics with three or more thread systems** Samit is a special weaving technique with two warps and two wefts. Twill weft composite weave. Special type of samit: monochrome silks
55	**Fabrics with three or more thread systems** Lampas is a special weaving technique too. Warp composite weave
56	**Carpets /Rugs** Special form of weaving, handicraft, combination of weaving and knotting. Fabric with pile.
57	**Knitted textiles** Knitted textiles consist of consecutive rows of loops, called stitches. As each row progresses, a new loop is pulled through an existing loop. Knitting may be done by hand or by machine. Hand-Knitters use two or more needles and work in horizontal direction.
58	**Felt** Felt is a non-woven cloth that is produced by matting, condensing and pressing fibres.
59	**Braiding** Crossing of two threads, diagonal to the edges. 2- or 3-dimensional.
60	**Embroidery** Decoration of a fabric/texile. Different methods: use of metal treads, silk threads, linen/cotton threads. Embroidery in different colours, same colour as the fabric. The embroidery can cover the textile completely or just in some decorative parts. Stitches used: running, stitch, couching stitch, satin stitch, cross stitch, buttonhole stitch etc.
61 - end	**Examples of textile objects** Embroidery/ different types of embroidery (coloured threads on monochrome fabric, Embroidery with metal- and silk-threads (3-dimensional), embroidery with metal threads (2-dimensional). Skirt, design by Oskar Kokoschka, a famous artist in Austria, dated 1907. He designed the skirt for his early love Lilith Lang. On the right side is a knitted jacket from the beginning of the 17th century. It was

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	made of silk and metal threads. Dalmatic of the Blue Ornate (vestment) of the church St. Augustin, Vienna. Tapestry from the so called Boucher Room in the Hofburg Vienna. They were designed by Francois Boucher and woven in Brussels. Two examples for Accessories: a fan and a pair of gloves. The fan is made of feathers and the gloves of leather. A pair of shoes with textile parts. Upholstered furniture, Boucher Room Hofburg Vienna (Tapestries) Golden Carriage, Liechtenstein Collection, Vienna (Textile inside) Carriage, End of the 19th century, Technisches Museum Vienna (Leather, Textile)

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