I WHAT ARE WE WEARING

WHY DO WE WEAR CLOTHES?

The main reason we wear different types of clothes and footwear is to stay warm, comfortable and safe. Evolution has stripped us of most of our hair, and for at least 65,000 years since migrating from warm Africa, *Homo sapiens* has covered its body with appropriated materials. As did our ancestors in the *Homo* genus.

Neanderthals crafted simple garments made from hides of the animals they hunted.

For millennia, the material used to make garments has depended on the native environment and the fauna and flora that inhabit it.

Not only do garments protect the body, throughout the ages they have also been linked to people's **opportunities, occupations, positions, affiliations, wealth, traditions, customs and fashion**. Garments are another way of expressing or concealing yourself. The coverings on animals perform a similar role.

CHANGES IN TIME

The trend in making garments//clothes has moved from simple to complex in all three areas over time:

- materials *(from what?)*
- technologies *(how?)*
- tools *(with what?)*

Most old traditional techniques and materials are still in use alongside new ones, although their importance has declined significantly. This means there are still those among us who know how to spin yarn with a spindle or a spinning wheel, weave fabric and sew clothes even though most yarns and threads and the fabrics made from them today are manufactured en masse industrially with dedicated machinery in spinning, weaving and sewing factories.

GEOGRAPHICAL SPECIFICATION OF THE DIFFERENT STAGES OF GARMENT MANUFACTURING

At first, most garments were made from local raw materials by local people from start to finish. Clothes were used from start to finish, as long as there were scraps that could still be made into something.

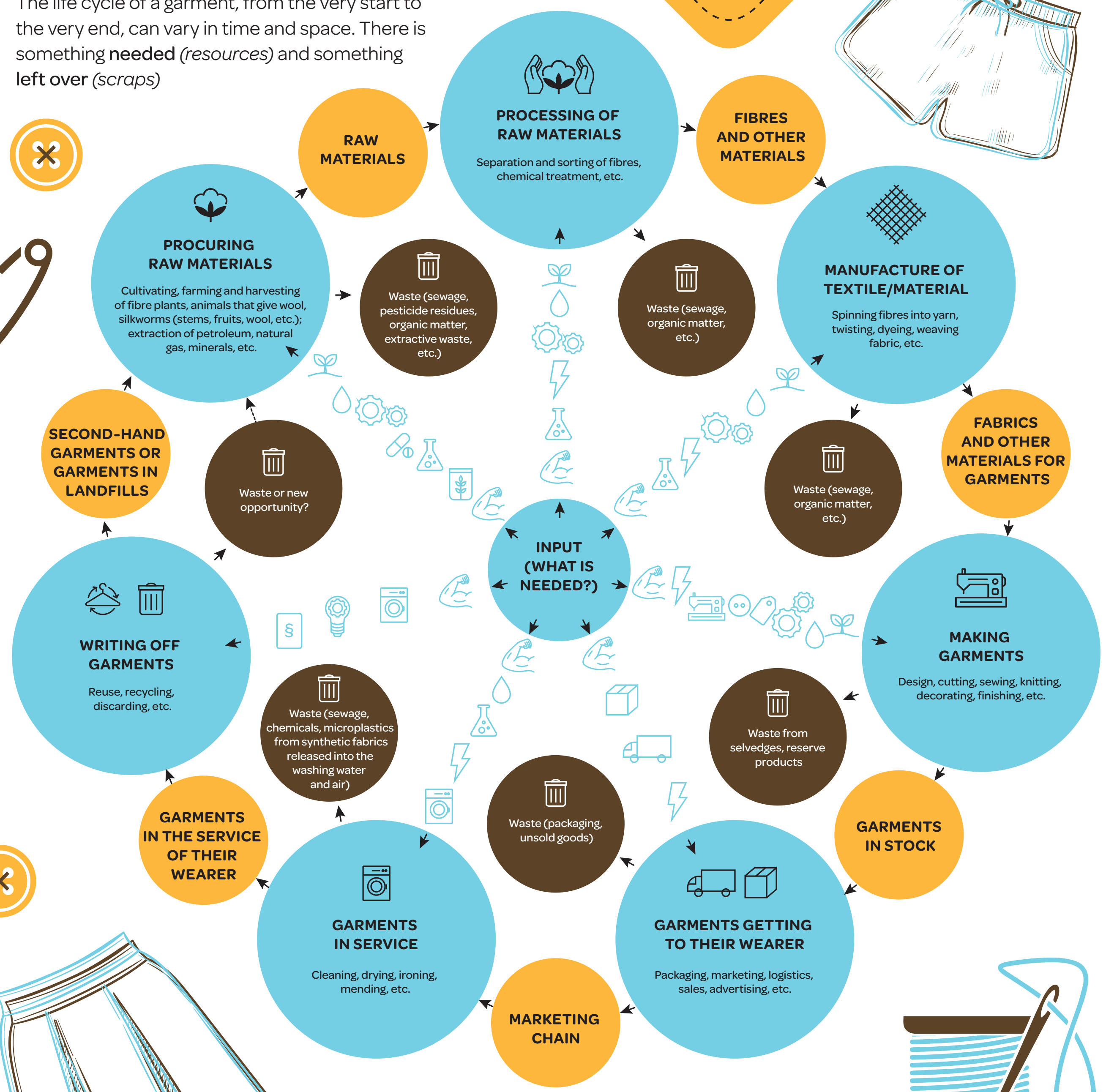
Over the millennia, various trades evolved for the different stages of the manufacturing process: flax farmers and processors, spinners, dyers, weavers, designers, seamstresses, tailors, until scientists, chemists, physicists, materials technologists, marketers, logistics specialists, salespeople and a myriad of other actors became involved in the process.

The cultivation and extraction of raw materials, the processing and manufacturing of materials, and the spinning, weaving, dyeing and sewing factories are now scattered in different parts of the world. This means that the shirt you purchased in a shop may have covered a much longer distance in the first half of its life than the person wearing it.

THE LIFE CYCLE OF A GARMENT

The life cycle of a garment, from the very start to the very end, can vary in time and space. There is something **needed** *(resources)* and something **left over** *(scraps)*

What are you wearing?
Where did you get it?
Did you make it?
How long have you been wearing it?



INPUT

land	medicinal products	transport
water	feed	packaging
work	chemicals	care
energy	tools	opening opportunities
machines	fastenings	legislation
	labels	

OUT OF THE CLOSET
The stories of our clothes

PHOTOS:
Neanderthal: istockphoto/gorodenkoff
Fashion: istockphoto/inarik
Textile factory: istockphoto/Utkucavuskizil

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II WHAT ARE OUR CLOTHES MADE OF? PLANTS I

All the raw materials used in making our clothes originate from nature one way or another: from plants, animals, fungi, bacteria, minerals or petroleum, coal and natural gas.

A large part of our clothes start from fine long **fibres**, which are transformed into **thread** and **yarn**, and then in turn used to produce **fabrics** of different weaves.

ORIGIN OF FIBRES

Natural fibres are fibres that can be found in nature

- plant fibres
- animal fibres
- mineral fibres *(e.g. asbestos, not used in garment manufacture)*

Chemical fibres are man-made

- **artificial fibres** *(chemically processed fibres from plant and animal fibres and proteins)*
- **synthetic fibres** *(fibres synthesised mainly from substances extracted from petroleum, coal and natural gas)*
- inorganic fibres *(carbon, glass, metal, etc.)*

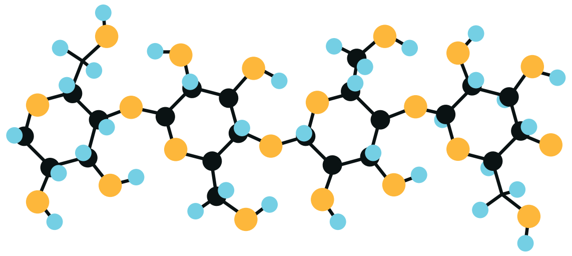
PLANTS

Plants have been used to make clothing items since ancient times, when herbaceous plants were fashioned into simple coverings.

Plant fibres have also been used for thousands of years.

Plants grow fibres for stiffness, strength and flexibility, and to distribute fruit.

Plant fibres are mainly composed of **cellulose**, the natural fibre in the cell walls of plants. Cellulose is a polysaccharide *(carbohydrate)* with a long chain, a stringy biopolymer made up of interconnected glucose molecules *(consisting of carbon, hydrogen and oxygen)*.



Cellulose is the most common organic matter on Earth, accounting for 33% of plant materials on average. Cotton contains 90% cellulose, wood 40–50%, hemp 75%.

The "patent" on cellulose is without a doubt held by plants. The structures made from plants have been tested and refined over hundreds of millions of years. Plants build complex, interconnected fibrous support tissues from cellulose and other related biomolecules *(lignin, pectin, hemicellulose, etc.)* that are both strong and flexible, and, if necessary, build numerous air-containing fibres for insulation or seed dispersal.

Cellulose is "designed" to be extremely durable and hard to break down, but not too durable as all plant fibres are eventually broken down in nature by fungi and bacteria.

Cellulose fibres absorb moisture well and become more even more durable when wet than when dry. A green tree branch is much more flexible and durable than a dried branch, which snaps much more easily.

The fibres used for human clothing are obtained from plant stems, seeds, fruits or leaves.

BAST FIBRE PLANTS

FLAX *(Linum usitatissimum)* is among the oldest fibre plants. Flax fibres were used to weave fabrics as far back as 8000 years ago. Linen was the number one fibre for clothing in ancient Egypt, Rome and Greece, and in medieval Europe. Flax has been grown for its fibres in Estonia for about 3000 years. In recent decades, flax cultivation and processing has declined significantly in Estonia and most flax mills have closed down.

The flax fibres are about the same length as the plant itself. The fibres also stretch into the roots, which is why the plants are not cut, but pulled up together with the roots to produce longer fibres. The shorter flax fibres separated during the cleaning process combined with the cleaning remains are known as tow. Linen cloth is durable and very effective at absorbing moisture, conducting heat and ventilating air.

↑ *Producing thread from flax.*

HEMP *(Cannabis sativa)* has been cultivated for thousands of years. Hemp fibre is similar to flax fibre, but it is stiffer and less uniform, yet strong and durable. Hemp also grows well in Nordic climates and continues to be an environmentally friendly choice.

The bast fibre from **NETTLE** stems *(Urtica dioica)* is used to make so-called Nordic silk. Nettle is abundant in many parts of the world and predates flax as a fibre plant. The extraction of fibres is labour-intensive and has remained under-utilised in the weaving industry. However, new technological solutions are being sought and nettles are being rediscovered.

RAMIE or Chinese grass *(Boehmeria nivea)* produces fibres that are similar to flax, but stronger, whiter and with silk-like lustre, making them highly sought-after.

JUTE *(Corchorus)* is a genus of annual plants growing in tropical and subtropical climates. Several species of jute produce a coarse, some-what brittle fibre that is used to make coarse-textured burlap rather than cloth.

There are various other plants used in different parts of the world that produce bast fibres for different textiles, weavings and wickerwork. For example, **velvetleaf fibres** originate from the velvetleaf plant *Abutilon theophrasti*, **kenaf** from the kenaf plant *Hibiscus cannabinus*, **corn fibres** from corn, **esparto** from halfah grass *Stipa tenacissima* etc.

OUT OF THE CLOSET
The stories of our clothes

PHOTOS:
Flax: istockphoto/Valeriy Lushchikov
Hemp: istockphoto/Wirestock
Nettle: istockphoto/Alter_photo
Ramie:istockphoto/Raul Ruiz
Jute: istockphoto /John Sarkar

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III WHAT ARE OUR CLOTHES MADE OF? PLANTS II

SEED FIBRE PLANTS

COTTON is the most important and widely used natural fibre in the modern clothing industry. Cotton is the seed fibre obtained from the bolls of various cotton plants.

Key species used to create different varieties:

- *Gossypium arboreum* or **tea cotton** – originates from Africa, grows to the size of a small tree
- *G. herbaceum* – **herbaceous cotton** shrub from India
- *G. hirsutum* – **common cotton** shrub from America
- G. barbadense – cotton originating from Peru

↑ *Cotton field and cotton bolls* →

1 kg = 10 000 L

Cotton cultivation started 7000 years ago in India and Mexico. Cotton arrived in Europe in the Middle Ages. It started out as a luxury commodity as it was difficult and time-consuming to grow and process. The introduction of machines made it faster, easier and cheaper, and cotton became a staple commodity.

Cotton cultivation is causing environmental problems related to the plant's high demand for water and the chemicals used to fight diseases and pests. It takes up to 10,000 litres of water to grow 1 kg of cotton. The processing of fibres – such as dyeing and bleaching – also requires a lot of water.

The airy, ultra-light, non-absorbent seed fibre of **KAPOK** is harvested from the seeds pods of kapok trees native to the American tropics. *Ceiba pentandra* is most widely grown for kapok in suitable climates around the world, as well as *Ceiba speciosa*, also known as the floss silk tree, which is known to produce "false kapok".

FRUIT FIBRES

Fruit fibre is mainly collected from the fruit of the coconut palm. Coir or coconut fibre is strong, coarse, durable and stiff, and is used mainly for making mats and brushes.

LEAF FIBRE PLANTS

The leaf fibres of various plants tend to be quite coarse and strong. They are mainly used to make ropes, mats and chunky weaving and wickerwork. They find little use in clothing.

Abacá Musa textilis leaves are used for Manila hemp. The plant is native to the Philippines, but is also cultivated elsewhere in the tropics around the world.

Phormium or **New Zealand flax** grows in New Zealand, while *Raphia or* **raffia palms** grow in Africa.

SISAL *Agave sisalana* is another well-known fibre plant that grows in tropical and subtropical America.

In Estonia, even **PEAT** has been used to produce fabrics. Peat fibre is also considered a leaf fibre, even though it is a mixture of different parts of plants *(containing different leaf fibres, seed hairs from Eriophorum vaginatum and more).*

PLANTS ALSO PROVIDE OTHER MATERIALS FOR MAKING FABRIC

Rubber tree *Hevea brasiliensis* produces a milky sap that coagulates on exposure to air and is known as the primary source of natural elastic rubber *(latex)*. It came into use in Europe in the 18th century to make raincoats and water-proof footwear, and remained the most important rubber material until the invention of synthetic rubber in the 1930s. It has now been rediscovered and is being used as a natural alternative to petroleum-based neoprene *(a foamed rubber with air bubbles invented in the 1930s)* to produce natural rubber neoprene Yulex-Pure® for wetsuits.

The strong needles of various plants have been used as sewing needles. Agave, for example, can provide you with a needle as well as a thread.

Have a look at how to get a sewing needle with thread from agave! →

Plants have historically been an important **source of dyes**, along with fungi, animals and minerals. Nettles and birch leaves, for example, are still used for dyeing purposes today.

Cellulose and some of the protein needed to make **artificial fibres** *(viscose, etc.)* are also sourced from plants *(e.g. soy protein and protein from peanuts).*

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The stories of our clothes

PHOTOS:
Cotton field: istockphoto /PRASANNAPiX
Cotton bolls: istockphoto /Leila Melhado
Cotton field: istockphoto /PhillipMinnis
Silk floss tree: Kati Kekkonen
Coconut: istockphoto/Kitri Aru Saputra
Sisal: istockphoto/SkyF
Peat: Maris Mägi
Kalypso: istockphoto/AnnaStills

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IV WHAT ARE OUR CLOTHES MADE OF? ANIMALS I

Dogs, guanacos, musk-oxen, beavers, yaks and other animals from all over the world also produce wool.

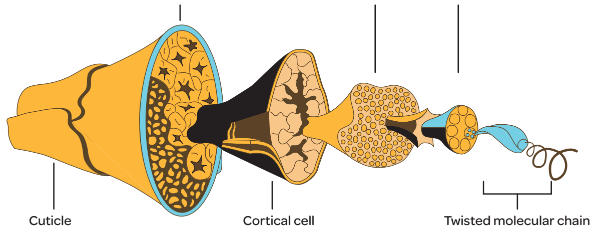
Animal pelts and hides have been used by humans for the longest period of time.

We use animals for wool and fur fibres, horsehair, bristles, feathers, down and various long silk fibres, dye pigments and many more clothing-related things.

WOOL

Wool is the fibre obtained by shearing or combing. Wool fibres consist of biomolecules, mainly proteins composed of amino acids, of different lengths produced in glandular cells.

The main building materials of animal fur *(including human hair and nails)* are keratins and collagens. In addition, they also comprise fats *(lipids)*, fat-like compounds *(cholesterol, lanosterol, etc.)*, pigments and other substances and the air pockets and tubes in between. The construction of wool fibres is complex and they are assembled following a species-specific pattern, similar to a 3D printer.



To acquire durability, water resistance and other properties, the glands on the skin also produce a variety of waxes and oils to treat and maintain the wool coat.

Fur serves a very similar function to the clothes worn by humans: to keep warm, protect against heat, divert moisture away from the body, be skin-friendly and lightweight. This is also the reason why our bodies usually react well to clothes made from wool.

ANIMALS PRODUCING WOOL

The wool fibres of different animals have varying lengths, durability, air content, surface structure *(fibres with a scalier, coarser surface cling together better and are easier to spin and felt than fibres with a smooth surface)* and other properties. Wool fibre has an impressive track record. It's the oldest known animal textile fibre used by man, and wool felt is believed to be the oldest known textile.

SHEEP OR DOMESTIC SHEEP *Ovis aries*

Sheep were domesticated around 10,000 years ago. Sheep have a layered coat and produce different types of wool: a base layer, an insulation layer and a mixed layer. Sheep are sheared once or twice a year. The wool is washed, scoured or combed, spun and twisted. The resulting yarn can be used to create a variety of knits and fabrics using different techniques.

The world's largest sheep farms and wool industries are in Australia, China, New Zealand, the UK and the US. In Estonia, sheep rearing has played a very important role for almost the entire history of human settlement in the area.

There are more than 200 breeds of wool sheep in the world and about 30 of them are found in Estonia.

MERINO SHEEP produce long, fine and much prized merino wool, used to make underwear for babies, base layers and much more.

Estonia's own breeds are the Estonian **KIHNU SHEEP**, the Estonian white-headed sheep and the Estonian dark-headed sheep.

DOMESTIC GOAT *Capra hircus*

The domestic goat was one of the first animals domesticated by humans. It was bred from the wild goat native to West Asia. Goats are reared for meat, milk and wool. The best known breeds for wool are the Angora goat and the Cashmere goat.

The wool produced by **ANGORA GOATS** is called **mohair**.

Mohair is softer, smoother and shinier than sheep's wool. Mohair fibre is expensive and difficult to obtain. Items made from it are pricey and considered luxury goods. Mohair is often mixed with other fibres.

The wool produced by a **CASHMERE GOAT** is known as **cashmere**.

Cashmere *(often in combination with silk)* has been used in India for thousands of years to create wonderfully lightweight and warm pashmina shawls. Cashmere only arrived in Europe only in the 18th century.

It's as soft as silk, incredibly warm, lightweight, has a good drape and is very valuable.

BACTRIAN CAMEL
Camelus bactrianus

The wool of the Bactrian camel, which was domesticated in Central Asia, is collected during the shedding period: the camel is not sheared. Camel wool has excellent warmth retention whilst also protecting against heat.

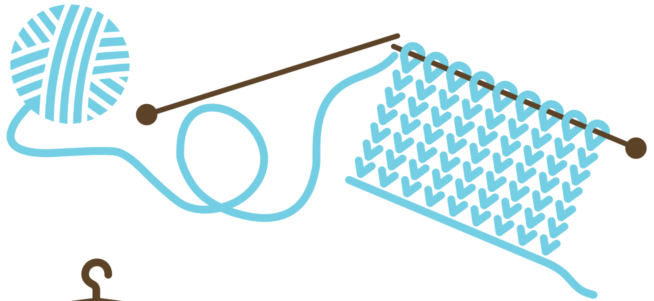
The camel's relatives in South America are the llama, alpaca, vicuña and guanaco.

THE ALPACA *Vicugna pacos* has been domesticated and is reared in many parts of the world, including in Estonia. Alpaca wool is soft, very warm and garments made from it do not wrinkle or bobble but they do mat more easily than clothes made from sheep's wool.

THE LLAMA
Lama glama is a prized wool and pack animal domesticated in South America.

THE VICUÑA *Lama vicugna* lives in the wild in the high alpine areas of the Andes and is a protected species. Its wool is warm, light, lustrous, rare and very valuable. To obtain it, the vicuña may be sheared once every three years.

The wool of the **ANGORA RABBIT** *Oryctolagus cuniculus angorensis* is known as **Angora wool**. Angora wool has excellent warmth retention, is soft, light, smooth and lustrous. It is rather difficult to spin pure Angora wool into yarn because the fibre is very slippery.



OUT OF THE CLOSET
The stories of our clothes

PHOTOS:
Merino sheep: istockphoto/PatrikStedrak
Kihnu sheep: Maris Mägi
Angora goat: istockphoto/Laflamme Imagerie
Cashmere goat: istockphoto/seakitten
Camel: istockphoto/Oskanov
Alpaca: istockphoto/MayaCom
Llama: istockphoto/GISTEL Cezary Wojtkowski
Vicuña: istockphoto/Wirestock
Angora rabbit: istockphoto/gydyt0jas

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V WHAT ARE OUR CLOTHES MADE OF? ANIMALS II

SILK AND ANIMALS PRODUCING SILK

Silk fibres are long protein fibres secreted by the glands of animals and used by a host of animals for a variety of purposes.

The silk fibre of domestic silk moths or silkworms is mainly composed of two proteins – long, strong fibroin molecules and an adhesive and protective sericin.

Spider web silk and byssus threads consist of proteins with very wildly differing properties *(elastic, adhesive, strong, flexible)* depending on the task for which they are used.

THE DOMESTIC SILK MOTH *Bombyx mori* or the silkworm is the most famous producer of silk. These insects were domesticated in China around 4500 years ago and have lost their ability to fly in the breeding process.

Once the silkworm eggs hatch, they feed on the leaves of the mulberry tree and grow for about 30 days. As they enter the pupal phase, they produce a cocoon of 3000-4000 metres of silk thread from a mixture of proteins produced by their glands that hardens when exposed to air. To obtain a homogeneous fibre, the pupae are killed and the silk fibres are rolled off the cocoons in hot water. If the pupae are left alive, a new generation of butterflies will hatch after three weeks.

Silk fibres are long, smooth and strong and very uniform in diameter. Silk from the domestic silk moth is also known as **mulberry silk** in reference to the mulberry tree they feed on. About 80% of natural silk produced in the world still originates from China.

Silkworm moth

Larvae of silkworm

Pupae of silkworm

WILD SILK

Silk fibre is produced by around 500 species of butterflies that feed on different plants worldwide. Several of these are also used to produce silk. This silk is known as wild silk, and is most widely produced in India. The best-known wild silk butterflies are *Antheraea assamensis* **(muga silkworm)**, *Antheraea paphia* **(tasar silkworm)**, *Samia cynthia* **(eri silkworm)**, the **Japanese silk moth** *Antheraea yamamai* **(tensan silkworm)** and the **atlas moth** *Attacus atlas* **(etlas silk)**.

Most wild silk and some of the silk made by silkworms feeding on mulberries is obtained by not interrupting the life cycle of the butterflies and by not destroying the pupae, i.e. the butterflies are allowed to emerge from the cocoon. As a result, many of the fibres in the cocoon are broken and shorter, but the butterflies are saved. This type of silk is also known as nonviolent silk or ahimsa silk.

Antheraea polyphemus

SPIDER SILK

The astonishing diversity and functionality of the protein composition of spider webs is the key to spiders' success and makes for fascinating research for scientists. Weaving fabric from spider silk is a big challenge, but it has been done. The silk collected from more than a million golden orb spiders *(Nephila inaurata)* was made to produce a cape on display at the American Museum of Natural History in New York. The production process, led by British art historian Simon Peers and his American colleague Nicholas Godley, took 5 years.

Production of spider silk →

SEA SILK

Many shells use byssus filaments to anchor themselves to the bottom of a water body. The long, thin byssus of *Pinna nobilis*, the **noble pen shell** living in the Mediterranean has historically been used to make sea silk. Byssus no longer holds any relevance as a material used to make fabrics, but its exceptional adhesive properties in water, as well as its high elasticity and strength, are being researched and tested to produce similar synthetic materials and to obtain the same proteins from bacteria and yeasts using genetic engineering.

Noble pen shell

Animals also provide other materials for making fabric

For thousands of years, the tendons and sinews of hunted animals have been used as thread or string, bones have served as needles and other tools, mother-of-pearl has been used to make buttons, pearls have served as ornaments, etc.

Many of the dyes we use for fabrics have animal origins, such as the red of cochineal and the purple of sea snails. The yarns of the traditional striped skirt from the Oaxaca region of Mexico are dyed with cochineal and the glandular excretion of the sea snail *Purpura pansa*, which takes on its colour in the sun.

Traditional methods of fabric weaving and yarn dyeing in Mexico

Milk protein or **casein** *(or casein protein-producing genes which are then transferred into bacteria)* from mammals is also used for artificial fibre production, which is used to make casein fibre and a casein plastic known as **Galalith**.

Casein buttons

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The stories of our clothes

PHOTOS:
Silkworm moth: istockphoto/alberto clemares expósito
Silkworm larvae: istockphoto/ MagioreStock
Siilkworm pupae: istockphoto/ Pilar Rodriguez
Wild silk: istockphoto/ Sunshower Shots
Spider: David Monniaux, Wikimedia Commons
Noblöe pen shell: istockphoto/ Damocean
Fabric weaving: Pexels / Los Muertos Crew
Casein buttons: Flickr / Karel Julien Cole

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VI WHAT ARE OUR CLOTHES MADE OF? CHEMICAL FIBRES I

Chemical fibres are man-made fibres made from chemically and otherwise processed substances.

ARTIFICIAL FIBRES

Artificial fibres are made by the chemical transformation or dissolution of natural fibres *(plan or animal)*.

MANUFACTURING OF ARTIFICIAL FIBRES

- gathering raw materials from nature containing molecules suitable for fibre production
- isolation of molecules
- formation of new fibres from molecules

English physicist and naturalist Robert Hooke was the first to experiment with engineered fibres in the 17th century, when he attempted to create a fibrous artificial silk inspired by **gelatine** silk fibres.

ARTIFICIAL FIBRES BASED ON CELLULOSE

- Pure cellulose was extracted in 1839.
- In 1884–1885, British chemist Sir J. W. Swan demonstrated fibres made from nitrocellulose *(nitrate fibre)*. This was treated with chemicals to convert the material into non-combustible cellulose.
- The process of passing nitrocellulose through the orifices of spinnerets to form fibres, which were hardened by blasting them with hot air and chemically converted back into cellulose, was introduced in 1889.
- In 1890, French chemist L. Despeissis patented the process by which fibres were produced by dissolving cellulose in cuprammonium. This was based on the 1857 discovery that cellulose could be dissolved in a solution of copper salts and ammonia and transformed back into cellulose after being stretched into fibres.
- In 1891, mass production of the first artificial fibre known as **Chardonnet silk** began.
- In 1891, the British chemists C. F. Cross, E. J. Bevan and C. Beadle invented a third method of producing viscose fibre, the most common today, from the thick syrupy *(viscous)* mass formed by treating cellulose mixture with sodium hydroxide.
- In 1908, a German company, I. P. Bemberg AG, began producing **cuprammonium rayon** or cupra.
- In 1905, the British silk manufacturer Samuel Courtauld & Company started producing artificial silk viscose using this process.

Rayon
↓

VISCOSE and cotton are very similar in their chemical composition. Cotton contains a small amount of other organic substances in addition to cellulose, while viscose is pure cellulose. Cotton fibres are short and this makes cotton fabric feel uneven to the touch. Viscose fibres, like all chemical fibres, can be made very long, so the fabric stays smoother and does not stain as easily.

MODAL is viscose at its best – very soft and with fine fibres.

TENCEL or **LYOCELL** is part of the family of viscose, being an improved variation thereof introduced in 1982. It's stronger and doesn't wrinkle as easily. The production of lyocell is less harmful to the environment than viscose.

Viscose fibres are virtually pure cellulose, meaning they can be reused and viscose waste can be made into new fibres *(just like paper)*. They are also „ingeste" by bacteria and fungi and decompose in nature.

ACETATE and **TRIACETATE** are also made from wood cellulose or cotton waste, using dry spinning and slightly different chemical treatments than viscose.

Pure cellulose is extracted from birch, spruce, beech and eucalyptus wood, as well as from cotton waste and **BAMBOO** *(bamboo viscose)*.

ARTIFICIAL FIBRES BASED ON PROTEINS

Fibres made from **casein** were patented in 1938. Treating it with softeners resulted in a relatively strong, waterproof, flexible and soft material that was used as a substitute for wool.

Fibres are also made from fibroin, the main chaperone protein in silk, water-soluble gelatin *(commonly referred to as fish glue)* found in **cartilage, bones and fish**, and from proteins found in **peanuts, soybeans and corn**. Nowadays, gene technology has been used to train bacteria and yeasts to produce many of these proteins in large quantities.

OTHER ARTIFICIAL FIBRES

Alginate is obtained from the chemical processing of algae.

NATURAL RUBBER can be used for both fibres and monolithic materials.

Harvesting natural rubber →

CHITOSAN is produced from **chitin**, mainly obtained from crustaceans such as crabs.

Chitin is a polysaccharide and the second most abundant long biopolymer in nature after cellulose. It's the main component in the cell wall of fungi and in the exoskeletons of insects, arthropods and crustaceans, and is also found in sponges, molluscs, cnidarians and annelids. The chitin molecule has a similar structure to cellulose, is also very durable, and there are only a few enzymes in nature that are able to break it down, the best known being chitinase.

Burying beetle (Nicrophorus vespillo) →

The exoskeletons of crustaceans contain chitin ←

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The stories of our clothes

PHOTOS:
Rayon: Niemayer~commonswiki, CC 3.0
Bamboo forest: istockphoto/somchaij
Natural rubber harvesting: istockphoto/structuresxx
Burying beetle: istockphoto/ SergeyTikhomirov
Crab: istockphoto/Delpixart

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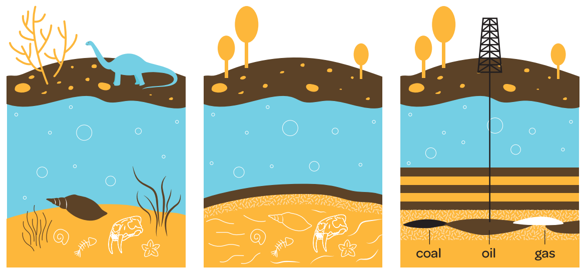
VII WHAT ARE OUR CLOTHES MADE OF? CHEMICAL FIBRES II

SYNTHETIC FIBRES

- **Petroleum, coal and natural gas** serve as the raw materials for synthetic fibres and materials.
- The substances derived therefrom are synthesised into chemically suitable molecules.
- These are transformed into long chain polymers and then used to produce long fibres.

Petroleum, natural gas and coal are fossil fuels formed hundreds of millions of years ago from the remains of living organisms that lived in the oceans and on land and were buried in soil or water and did not fully decompose. Part of this buried mass has been converted into a thick 'soup' of energy-rich *(solar energy that was once stored!)* organic and inorganic substances we know as petroleum as a result of lack of oxygen and exposure to enormous heat and pressure underground.

Even synthetic fibres and plastics ultimately come from plants...



The first synthetic plastic was Bakelite *(patented in 1909)*. This was not used to make clothes.

NYLON (polyamide) is the first real synthetic fibre, invented in 1935. It wasn't called nylon until 27 October 1938. Nylon became the generic name for all synthetic fibre-forming amides that have a chemical structure reminiscent of proteins and are characterised by exceptional tenacity, strength and moderate elasticity. The first pair of nylon stockings was sold in the USA on 15 May 1940 and they gained popularity very quickly.

POLYESTERS are synthetic polymers with repeating ester bonds. Natural esters include amber and tree resin. There is a wide variety of synthetic polyesters with different properties, the most widely used being polyethylene terephthalate *(PET, used to make plastic bottles and fleece)*. Polyester is resistant to dyeing and chemical substances. Polyester fibres are the most widely used synthetic fibres in the global textile industry. Synthetic fibres with different properties and uses are known by different names, such as **crimplene, dacron, mylar, polyester, terylene, thermolite, trevira** and **lavsan**.

Polyester fibre ↓

ACRYLIC

The potential of polyacrylonitrile as a raw material for synthetic fibres was investigated in the 1930s, and in 1941 DuPont Co synthesised the first acrylic fibre. Acrylic is easily charged and bobbles.

ELASTANE *(spandex)* is an extremely stretchy and elastic synthetic fibre. It's usually spun as a multifilament yarn.

- 1942 – Invention of polyurethane
- 1958 – Invention of polyester-polyurethane blend, elastane, by J. Shivers, a chemist at DuPont
- 1959 – Marketed under Fiber K
- 1962 – Marketed under Lycra

ELASTANE is easy to dye and is commonly used to make elastic fabrics, swimwear and hosiery *(mostly in combination with other fibres)*.

↑ *Sportswear made of elastane*

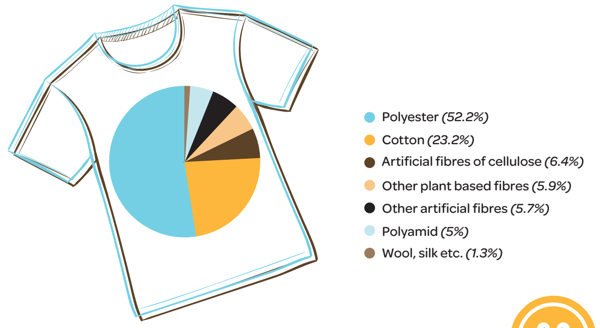
In general, synthetic textiles are durable, lightweight, easy to care for and clean, and they dry quickly. Garments made of 100% synthetics block ventilation, causing perspiration, and many of them generate electrostatic energy. Synthetic fibres start to melt at high temperatures.

Man-made synthetic materials are designed to be all too durable for nature – they degrade slowly and there are few organisms that are able to recycle them in the wild. Petroleum is digestible to quite a lot of bacteria *(they are also used to clean up oil spills)*, but there are very few *(as far as we know)* plastic-eating bacteria in the wild.

In 2016, Japanese scientists discovered a bacterium *(named Ideonella sakaiensis)* in a landfill that can break down PET polymer *(which is what our polyester fleeces are made of)* into small pieces and digest them. It produces a special enzyme that can break down a plastic bottle in 6 weeks under good conditions. Recently, some other plastic-degrading bacteria, yeast strains, fungi and protozoa have been discovered.

However, we can't rely on bacteria alone to tackle the problem of excess plastic and clothes as well as microplastics that we are learning more about.

Synthetic fibres make up about 65% of all textile fibres produced today, most of which are polyester.



INORGANIC FIBRES

Inorganic fibres are carbon fibres, ceramic fibres, glass fibres, metal fibres and metal-coated fibres.

Historically, metallic and metal-covered fibres have been most widely used in clothing. These are used to make luxury fabrics such as lamé and brocade.

BROCADE is a heavy fabric *(originally of silk, now also of cotton)* woven on Jacquard looms and decorated with ornaments interwoven with metal or metal-covered threads *(originally gold and silver threads)*.

OUT OF THE CLOSET
The stories of our clothes

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VIII HOW ARE CLOTHES MADE? TECHNOLOGIES I

Most garments past and present are made from fabrics woven from yarn or thread spun from fibres obtained from a variety of raw materials.

PREPARING FIBRES FOR SPINNING

Wool from animals is washed, carded or combed into aligned fibres to produce a continuous **sliver** suitable for spinning – carded or combed wool.

To separate and clean the stem fibres, the stems are retted, broken, beaten, carded or combed to produce a fluffy **sliver** for spinning.

Wool carding ↑ *Carding vegetable matter* ↑

To obtain chemical fibres, the raw material is treated chemically, resulting in long, uniform fibres.

FROM FIBRE TO YARN AND THREAD

SPINNING is the process of making yarn or thread from fibres.

TWISTING is the process of twisting yarns together to produce a stronger and coarser yarn or thread.

Spindle, spinning wheel and spinning machine ↑

FROM YARN TO FABRIC

The properties of the fabric depend on the material, the weight of the yarn and the way the threads and yarns are linked together in the weave. Weaving techniques determine the fabric's density, lustre, smoothness, softness, pattern, stretch, etc.

For example, cotton is used to make **terry, flannel, jersey, velvet, lace, satin, muslin, denim** and **other cotton fabrics.**

FABRIC MAKING METHODS

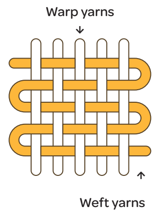
When braiding, the yarns are interlaced in a certain order. Ribbons, strings and belts are made in this manner.

Belt braiding →

FELTING is the oldest fabric-making technique. Felt is not knitted, it is formed as the scaly exterior layer of wool fibres interlock with one another by wetting and rubbing the wool with soapy water.

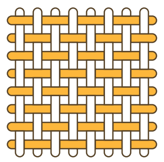
WEAVING between warp yarns with weft yarns

Warp yarns are the longitudinal threads running along the fabric. The warp is set up on the looms in the required length, density and width. Weft yarns are then woven one by one between the warp yarns following a certain pattern, i.e. with a certain weave.

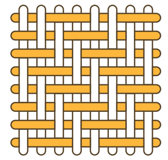


Three basic weaves and their combinations are used.

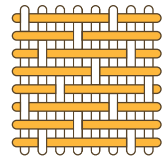
PLAIN WEAVE: one warp yarn goes over one weft yarn and under the other, and vice versa on the next row. Thin **batiste, organza and chiffon**; medium-weight **lace, canvas** and **bouclé**; coarse **burlap** and **tarpaulin**, for example, have a plain weave and derivative weaves include **Aida cloth** and **Gingham** or **Vichy check** with a woven pattern.



TWILL WEAVE: the weft yarn covers several warp yarns and then goes under several warp yarns, forming diagonal lines on the fabric. **Denim** and **broadcloth**, for example, have a twill weave.



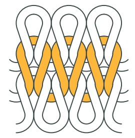
SATIN WEAVE: each warp yarn covers at least five weft yarns *(warp-faced satin)* or each weft yarn covers at least five weft yarns *(weft-faced satin)*. The result is a smooth surface with a beautiful lustre. Satin-weave fabrics include **satin, duvetyn, patterned brocade** and **damask**.



The tools for weaving fabrics have been improved over time.

Various types of looms ↑

KNITTING is the process of making textiles and knits in stitches from yarn or thread loops. Knitting needles are used to knit by hand. A variety of knitting techniques can be used, such as knit stitching, stockinette stitching, brioche stitching, lace stitching, etc.



Haapsalu shawls are made of extremely fine yarn →

MACHINE KNITTED stretchy fabrics are known as **jersey**. Many of our most common clothes such as elastic swimwear, sportswear, tights, socks, T-shirts, etc. are made from jersey fabrics.

CROCHET is the process of creating textile items from yarn using a crochet hook. The crochet technique can be used to make thick crochet designs as well as fine and delicate lace *(Irish lace, hair-pin lace, filet crochet, etc.)*.

NAALBINDING is the process of creating items by forming loops of yarn with the tip of a blunt bone or wooden needle and interweaving them. The result is dense, non-elastic and they do not unravel. Naalbinding predates knitting and crochet, and was known as far back as the Stone Age.

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PHOTOS:
Wool carding: istockphoto/SafakOguz
Carding vegetable matter: istockphoto/houdre
Spindle: istockphoto/IKvyatkovskaya
Spinning wheel: istockphoto/ Stephanie Murton
Spinning machine: istockphoto/antoniotruzzi
Belt: Maris Mägi
Loom 1: istockphoto/Zephyr18
Loom 2: istockphoto/Grzegorz Sulkowski
Haapsalu scarf: Lace by Cassie Rosse
Crochet: istockphoto/Liudmila Chernetska
Naalbinding: Bård Løken/Anno Norsk skogmuseum

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IX HOW ARE CLOTHES MADE? TECHNOLOGIES II

The resulting fabrics are then finished to obtain a material with the desired properties for making clothes with different functions.

Finishing refers to the chemical or mechanical processing of a fibre, yarn or fabric to change its properties.

Various processing methods can be used to modify:

- **appearance** *(what we can see)* – colour, pattern, lustre, puckering, etc.
- **texture** *(how it feels to the touch)* – softness, smoothness, density, coarseness, puckering, etc.
- **functional properties** *(special properties)* – cleanliness, dyeability, elasticity, water resistance, water absorbency, resistance to moths, stain resistance, durability, charging, pilling resistance, heat and fire resistance, level of creasing, etc.

Fibre, yarn and raw fabric properties can be significantly altered by applying different finishes or after-treatments.

Chemical or wet processing involves the use of water and a wide variety of chemicals – resins, alkalis, acids, salts, ammonia, dyes, glues, starch, glycerine, oils, gelatine, enzymes and a host of other substances.

During **mechanical or dry** processing, fabrics are rolled, napped, stretched, beetled and treated in a number of other ways.

Flannel is a classic napped cotton fabric →

Chemical and mechanical treatments are often combined.

Some finishing techniques have been around for a very long time, such as boiling, bleaching, fulling and dyeing.

FULLING is the process of rubbing or bruising wool fabric or knitwear with hot water *(adding soap or lye)* to make the material more durable and thick. Wool fibres then combine in a similar way to felting. Accidental fulling can occur when wool items are washed with a programme that is too hot and too intense. This will, for example, shrink down a formerly large sweater and make it much thicker.

PROPERTIES

The properties of clothing depend on

- the properties of the constituent materials or fibres of the fabric
- how these materials are made *(fabric or knit technology)*, e.g. jersey fabrics have more stretch than twill fabrics, regardless of fibre.
- the finishing

There are countless combinations available today.

↑
Fibres vary in structure and chemical composition, but also in thickness, length, shape and surface texture

FIBRE LENGTH, THICKNESS, SURFACE AREA AND WEIGHT

Natural fibres *(except silk)* are short. Silk fibres, artificial and synthetic fibres are long. It is more difficult to spin short fibres and the result is more uneven.

The scaly exterior of wool fibres promotes bonding when spinning, felting and fulling. Finer and smoother fibres can be used to create thinner and more delicate fabrics. Fibres with a smooth surface feel hard *(synthetic fibres)* or slippery *(silk)* to the touch, whereas fibres with an uneven surface feel soft *(cotton, wool)*. Natural fibres *(except silk)* and artificial fibres are generally **heavy**, while chemical fibres and natural silk are **light**.

All natural fibres and some artificial fibres *(viscose, modal)* **absorb moisture**. Sheep's wool, silk and viscose can soak up large amounts of moisture without feeling damp against the skin. Silk dries fast while cotton, linen and wool dry slowly. Synthetic fibres and some artificial fibres *(acetate)* are **moisture repellent**. They dry fast but feel damp against the skin when sweating.

Plant fibres become stronger when wet, animal fibres on the other hand become weaker. Synthetic fibres remain unaffected by moisture.

STRETCH AND ELASTICITY

Elastic fibres have more stretch than regular fibres. This includes natural rubber and synthetic elastane. Polyamide is a highly stretchy fibre, polyester has medium stretch, cotton and linen are virtually inelastic.

Flax, cotton and viscose fibres are inelastic and inflexible. These materials also crease easily. Polyester is added to them in order to reduce creasing. The addition of 5% elastane fibre makes inelastic or low-stretch materials more elastic and improves shape retention.

INSULATION AND THERMAL CONDUCTIVITY

Items made of insulating fibres *(wool, silk)* will be warm. Cotton, linen and viscose are excellent conductors of heat, meaning that you will not feel hot in clothes made from them.

Synthetic smooth materials feel cool, but their insulating properties can be improved by napping as well as by using fibres with air ducts. The more air a material can hold, the warmer it is.

THE TEMPERATURE RESISTANCE of fibres is important for clothing care, finishing and dyeing. Different recommendations apply for washing and ironing different materials.

Synthetic fibres melt when ironed at excessive temperatures. Silk is also sensitive to heat.

THE CHEMICAL STABILITY of fibres is important for washing, stain removal, dyeing and finishing. Cellulose fibres are resistant to alkalis but vulnerable to acids.

Protein fibres *(wools, silks)* are not resistant to alkalis, but can withstand acids. Most synthetic fibres are resistant to chemical substances.

The charging of fibres depends on their moisture content *(the drier the fibre, the more electrified it becomes)*. Humidity and friction also play a role. Synthetic fibres and acetate are extremely easy to charge. Wool and silk become charged in dry air. Natural plant fibres and viscose have a high moisture content and cannot be charged.

MIXED MATERIALS

Many of our fabrics are made from mixed materials, i.e. combining different types of fibres. This way it is possible to complement the weaknesses of one material with the strengths of another.

The biggest downside of mixed materials is that it is much more difficult to reuse them as opposed to reusing mono-material clothing.

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The stories of our clothes

PHOTOS:
Flanel: istockphoto/Dario Pena
Fulled knitting: Maris Mägi
Stetch stocking: istockphoto/Petr Smagin
Melted synthetic fabric: istockphoto/Ivan Halkin

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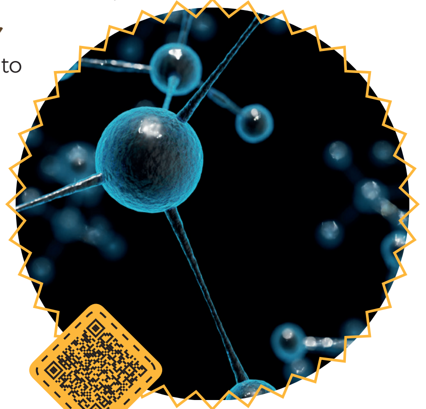
X WHAT ARE OUR CLOTHES MADE OF? CHEMICAL FIBRES III

The clothing industry is constantly innovating in step with scientific discoveries about materials, their structure and technologies.

It is always on the lookout for new and effective materials for special protective clothing *(fire-resistant, impact-resistant, water- and oil-resistant, anti-static, anti-bacterial, chemical-resistant)*.

NANOTECHNOLOGY has also made its way to garments. Using ultra-tiny particles, thin membranes and carbon structures as thin as molecules, materials with novel properties are being created.

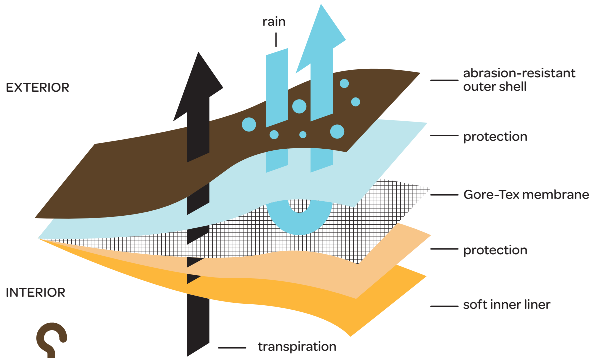


Nanotechnology →

We are seeing increasingly more "smart materials", such as those that selectively allow water and air to permeate in the right direction and change their properties depending on humidity and temperature.

Many ideas are still inspired by nature. For example, biomimicry, or the emulation of nature, and bionics *(biologically inspired engineering)* offer exciting new possibilities.

Many will be familiar with the **Gore-Tex** material, created in 1969 by father and son Wilbert L. Gore and Robert W. Gore. The Gore-Tex membrane with tiny pores is made of polytetrafluoroethylene *(PTFE)*, which is impermeable to large water droplets but penetrable to evaporating water molecules and air. It is a synthetic crystalline polymer composed of carbon and fluorine atoms, also known as Teflon, that was discovered in 1938. The pores in the membrane are 20,000 times smaller than a drop of water, but 700 times larger than a water molecule.



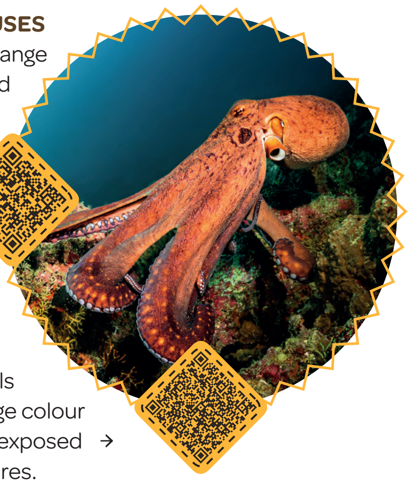
BIONICS AND BIOMIMICRY

The study of the properties, construction, structures and functionality of natural materials is both fascinating and useful – humans can mimic the tricks nature has devised.

Materials that mimic the **scaly surface of shark skin** are used to make, for example, swimwear that minimises resistance to movement when swimming and reduces the formation of eddies on the surface of the fabric.

The sole patterns of running shoes emulate the scales on the **skin of a snake**.

The ability of **OCTOPUSES** and **squid** to swiftly change colour has also inspired fabric manufacturers.



You can change the colours of ChroMorphous with your smartphone as the fabric contains electronics.

There are also materials being made that change colour on stretching or when exposed to different temperatures. →

While studying pine cones, Julian Vincent invented a smart fabric in 2004 that adapts to **temperature changes**. Pine cones respond to increased humidity by opening their scales. The smart fabric mimics this property by opening its pores when the wearer is warm and closing them when it is cold.

WATER- AND DIRT-REPELLENT FABRICS have been created by emulating the surface structure of the lotus leaf.

ENVIRONMENTALLY FRIENDLY DEVELOPMENTS

Considering environmental impacts has become increasingly important. This includes finding ways to use less energy, raw materials and harmful chemicals in manufacturing, applying biotechnology to produce new materials, and making more efficient use of waste by applying the principles of the circular economy.

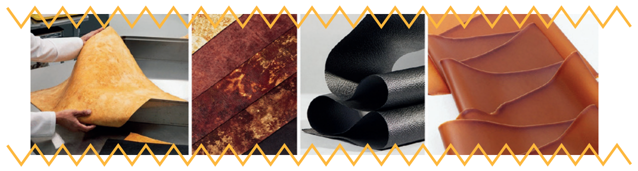
NEW MATERIALS AND TECHNOLOGIES

Protein-based **microsilk** is produced by yeasts implanted with genes responsible for the production of spider web proteins.

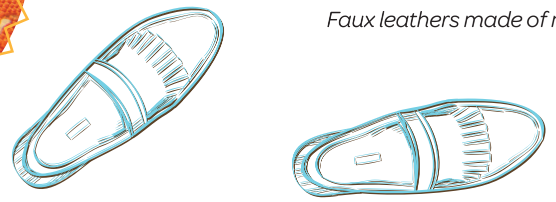
Development is under way to come up with more sustainable alternatives to natural leather and artificial leather made from non-renewable raw materials, such as **Piñatex** made from pineapple leaves, **cork leather** from the cork oak bark, **PineSkins** made from pine bark and leather-like materials grown from various mushrooms *(MuSkin, Mylo)*.

SKOBY is a leather-like material produced from a symbiotic culture of bacteria and yeast used to prepare the popular tea drink kombucha. The mushroom grows by consuming sugar.

MYLO is faux leather made from mycelium.



↑ *Faux leathers made of mucelium*



Piñatex is made by processing pineapple leaves; the separated fibres are washed and dried. The dried mass is then converted into a fibrous bulk material to which polylactic acid is added to yield a felted material.

Bananatex is made from banana plant fibres and treated with wax.

Process of making Bananatex →

Vegea is grape leather made from grape skins, stalks and seeds left over from the winemaking process. Fruit residues are used to make leather-like materials *(e.g.* **Fruitleather Rotterdam**). The material **S Café** is made from repurposed plastic and coffee grounds.

MATERIALS FOR REUSE

The circular economy also takes its cue from nature. There is no waste in nature - everything is taken up by someone else again and again.

The textile industry is moving increasingly towards the use of recyclable materials to transform them into new fibres, materials and products. This helps cut waste, energy consumption in the manufacturing of new products, and the need to tap into new natural resources.

Nylon can be recycled into **nilit**.

New **polyester fibres** are increasingly made by recycling plastic bottles to produce fleece and other fabrics.

Denim waste is used to make new fibres, yarn and fabrics.

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PHOTOS:
Nanotechnology: iStock/~UserGI15994093
Octopus: iStock/Volodymyr Ivanenko
Water droplets on a leaf: iStock/Yummy pic
Water-repellent fabric: iStock/a_Taiga
Skoby: Istock/ SewcreamStudio
Mycelium-based leathers: Vanderlook et al (2021), CC 4.0
Process of making Bananatex: Bananatex, CC4.0

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XI MAKE IT ATTRACTIVE AND FUNCTIONAL

Dyes, patterns, accessories, embellishments are used to make clothes look attractive.

For clothes to be easy to put on, wear and take off, they need to have the right fit *(fashion, cuts)* and functioning fastenings or closures.

DYES

Yarn and fabrics alike have been dyed for thousands of years using dyes extracted from plants, fungi, minerals and animals.

W. H. Perkin introduced the first synthetic dye in 1856. Today, we know how to produce more than 8,000 shades of synthetic dyes, with 90% of all fabrics dyed synthetically.

Fabric dyeing requires a lot of energy, chemicals and water. It generates a lot of waste water and chemical residues, dyeing being one of the most polluting activities in the entire textile industry.

PATTERNS AND KNITTING PATTERNS

COLOURFUL PATTERNS can be worked into fabrics using coloured yarns. Patterns can also be printed onto the fabric later.

RELIEF PATTERNS are made using a variety of knitting and weaving techniques, both by hand and machine. Burn-outs, abrasion and glueing techniques are also used. Patterns are made using embroidery, hemstitching, sewing on embellishments *(beads, sequins, etc.)* and several other techniques.

SEWING

Sewing is one of the oldest forms of textile work. Before the invention of spinning and weaving, people in the Stone Age sewed garments from animal skins, using needles made of bone, horn or ivory, and various animal "threads" *(tendons, intestines, veins).*

The sewing machine was invented in the 19th century. Sewing on an industrial scale first began in the 20th century, but skilled sewing by hand is still honoured for producing high-quality custom items *(individual sewing, tailoring)* and as a creative outlet for textile artists and crafters.

FASTENINGS

Strings, ribbons and **belts** have been used for a very long time and are still in use today. Strings and ribbons can simply be tied up, make use of holes reinforced with eyelets which they can be threaded through.

A **brooch** is a metal *(rarely made of bone or other material)* clothing fastener and jewellery worn on the chest since the Bronze Age 4,000 years ago. It consists of a body and a fastening pin. Brooches have changed in shape and decoration over time, as well as varied from region to region. They are rarely used as practical fasteners nowadays, but **safety-pins** serve as simplified derivatives of their function.

The **HOOK-AND-EYE** closure was introduced in England in the 14th century. They were first produced by bending wire by hand. Mass manufacture began in 1643. Hooks made it possible to put on corsets without help. A laced corset had to be tightened behind the back by an assistant.

A **BUTTON** is a fastener that works in combination with a buttonhole. Buttons come in a wide variety of sizes and shapes, and can be made of different materials *(metal, wood, bone, plastic, ceramics, shells of snails and clams).*

The earliest engraved seashell buttons discovered in the Indus Valley civilization are 4,000 years old. They were likely primarily decorative. Buttonholes first came into use in the Middle Ages, and since then they have evolved along with garments.

Buckles were used in the army in Ancient Rome to secure military equipment.

SUSPENDERS, GARTERS, SOCK AND STOCKING HOLDERS were in use until more practical solutions were invented. These days, they are mostly used as accessories. They lost their purpose once socks and stockings were fitted with elasticated hems and could stay on without support.

Zippers are closed and opened by pulling a slider along the teeth of the zipper. In 1851, the inventor of the sewing machine, E. Howe, was granted a patent for a mechanism similar to a zipper. In 1893, W. Judson invented the clasp locker. In 1913, Swedish designer G. Sundbäck designed the modern zipper.

How does a zipper work? →

HOOK-AND-LOOP FASTENERS were inspired by the hooks on the burs of burdock, which cling to the hairs of animals to carry seeds. The fastener *(consisting of two sides, one with hooks and one with loops)* was invented in 1941 by Swiss engineer George de Mestral, after a hunting trip with his dog in whose coat the burs got stuck. He acquired a patent for it in 1951.

PRESS STUDS AND RIVETS have been used in the garment industry as fastenings and embellishments for more than 150 years, since Levi´s jeans started using rivets for reinforcement. Press studs, rivets and rivetable buttons made of all kinds of different materials are widely used today for decorative purposes and as practical fasteners.

RUBBER ELEMENTS, RUBBER BANDS and other elastic additions have been used in the making of garments for over 150 years. The mass manufacturing of rubber bands started in 1923. Elastic and stretchy materials have been used for thousands of years. Originally, these would have been animal guts and rubber made from plant latex. Later on, synthetic elastic materials were added.

PHOTOS:
Colourful patterns: istockphoto/tupungato
Relief patterns: istockphoto/intek1
Hand sewing: istockphoto/Viktoriia Zinovieva
Singer sewing machine: istockphoto/rweisswald
Sewing machine: istockphoto/Zinkevych
Sewing factory: istockphoto/inside-studio
Corset: istockphoto/Aleksei Gorelov
Stocking holder: istockphoto/capdesign
Burdock: istockphoto/© Viktor Kintop
Hook-and-loop fastener: istockphoto/curtoicurto
Leather jacket with rivets: istockphoto/ET Visual Art

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XII EVERYTHING HAS ITS IMPACT

USE OF RESOURCES

A wide range of resources are used throughout the life cycle of clothes.

- **Land** – for cultivation of fibre plants and rearing of wool animals, mines for extracting raw materials for synthetic fibres, land under industrial buildings, landfills for storing waste, etc.
- **Water** – for the cultivation, harvesting, cleaning, processing, dyeing, washing, etc. of raw materials.
- **Energy** – for manufacturing, transport, marketing, care of clothes, etc.
- **Mineral resources** – metals, oil, natural gas, coal.

POLLUTION AND WASTE

The manufacturing, use and disposal of clothes also generates considerable amounts of waste.

- **Water pollution** – chemical pollution, microplastics, detergent residues, etc. The dyeing and finishing of textile products is responsible for an estimated 20% of global water pollution.
- **Waste** is produced in the form of scraps *(selvedges edges, reserve products, ends of fabric spools, etc.)* at various stages of production, from unsold goods and after disposing of old clothes.

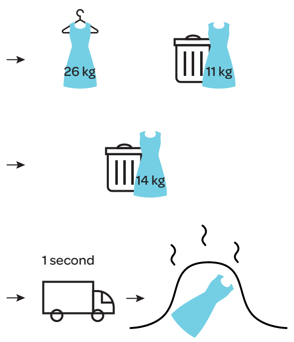
Exponential growth in clothing manufacturing and consumption has resulted in an explosion of waste.

Per-capita clothing purchases in the EU have increased by 40% since 1996 due to a sharp drop in prices. This has resulted in a shorter life span for garments.

Europeans buy **26 kg** of textiles a year and throw away around **11 kg**.

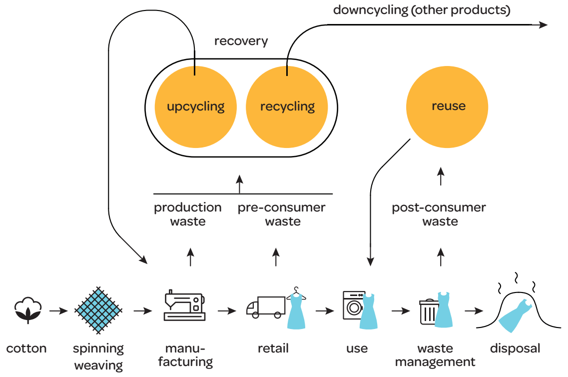
The average Estonian throws away **17 kg** of clothes every year, with **14 kg** going to the bin.

Every second, a truckload of clothes goes to a landfill or incinerator somewhere on the planet.



Most second-hand clothes have been shipped off to developing countries for decades, where they cause a host of problems

From 2025, further exports of textile waste from Europe will be banned, and we need to tackle the problem right here. The principle of the circular economy is increasingly being used to address the waste problem – how to reuse textile waste and turn it into new materials and things.



Greenhouse gas emissions from all the energy invested in clothing over their lifetime are alarming in the face of climate change. The carbon emissions from the clothing and footwear industry are greater than those from shipping and air traffic.

Clothing manufacture is associated with a range of **social problems**. Inexpensive clothes are often made in developing countries by minors working 12 hours a day in very poor conditions for meagre pay. Abuse, harassment, detriment to health, etc. are widespread.

Who made my clothes? →

FASHION

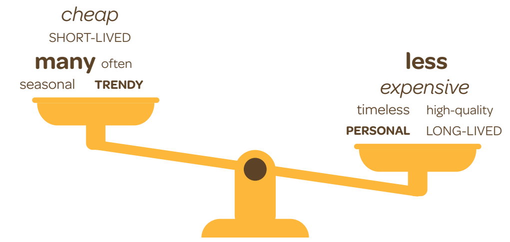
Many species in the animal kingdom, such as the mountain hare, have a distinct winter and summer coat. This has remained constant for millennia and is very practical: a brighter and warmer coat in winter versus a thinner and browner coat in warmer weather.

People's clothing preferences have changed over time. Even now, there are many different fashions and different ways of making garments. There is high fashion, high-quality bespoke sewing and tailoring to create garments for a specific person, usually involving several fittings. On the other hand, mass manufacturing and fast fashion have become increasingly prominent.

Fast fashion is all about rapidly changing clothing styles and constantly generating huge quantities of new, super-cheap clothes that consumers tend to discard without a second thought. Fast fashion brands put out 52 collections a year, covering one season in just a week…

OUR CHOICES MATTER

- Buy **fewer items**, less frequently, only go for things you actually need and aim for the highest possible quality.
- **Take care of what you use** – extend the life of your garments.
- Buy from **local makers, small businesses and designers**. Avoid fast-fashion retailers.
- Buy **second-hand clothes** and keep in mind that this too should be done only when you need the items!
- Choose **sustainably manufactured** products *(look for GOTS, Oeko-Tex or other eco-labels).*
- Go for **natural materials** *(wool, linen, cotton, hemp)* and **cellulose-based artificial materials** *(Lyocell, loncell-F, viscose, etc.).* For synthetic materials, prioritise **recycled materials** *(e.g. polyester made from plastic bottles),* and prefer **mono-materials** to composite materials where possible.
- **Donate** your used clothes to give them a second chance when you can, or use them for something else.
- **DIY** as much as you can – sew, mend, find new uses.
- Find your **personal style** and do not rely on advertising that only entices and drives you to consume more!



ECO-LABELS

GOTS *(Global Organic Textile Standard)* is a certification awarded to fabrics made from organically grown cotton. It certifies not only that the fabric and dyes are safe, but also that all the people involved in the production of the fabric have been treated fairly and well, and that the environmental impact of all stages of fabric production has been minimised.

The **Oeko-Tex label** identifies clothing made from other materials that are also produced in a way that is safe for people and the environment. There is quite a wide range of eco-labels for clothes.

OUT OF THE CLOSET
The stories of our clothes

tartu nature house
Estonian Research Council

PHOTOS:
Textile waste: istockphoto/Srdjanns74
Cycle of textile waste: Reet Aus
The mountain hare in the summer: istockphoto/Karl Ander Adami
The mountain hare in the winter: istockphoto/Wayne Marinovich

XIII EXTENDING THE LIFETIME OF CLOTHES

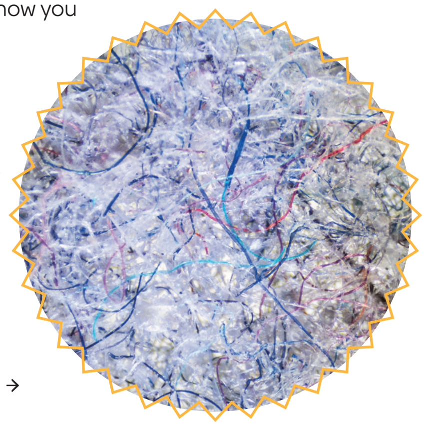
You can make your clothes last longer by caring for them properly and, most importantly, by valuing them.

We wear the right clothes for the right situation – work-wear for work, festive clothes for parties, sportswear for sports, etc.

Clothes made of different materials and different types of fabric are cared for differently because of their different properties.

If your clothes end up damaged while protecting you – such as a hole, a tear, an unexpected stain, a missing button, etc. – examine the extent of the damage and determine if and how you can repair it. Perhaps discarding it is not the only solution...

Clothes will gradually **wear and tear** as they are worn and washed, and pieces of fibre will fall out.



A large part of household dust is made up of clothes fibres →

When cleaning the washing machine filter, we can identify what kind of laundry we washed by looking at the fibres.

Acrylic knits release the most microplastic fibres *(up to 730,000 particles per wash)*, while polyester fabrics release 1.5 times less and polyester-cotton blends about 5 times less.

Microscopic fibres in the filter of a washing machine →

CARE

The care instructions for clothes are printed on a label inside the garment, or sometimes on the garment itself.

WASHING

Washing instructions specify the highest temperature at which a particular item should be washed. You can always opt for a lower temperature. In the case of mixed fabrics and materials, this is based on the most delicate fibre. Some clothes require delicate washing, or only washing by hand, or even waterless dry cleaning.

DRYING

There are many variations on spin drying, wringing and drying laundry, and labels specify these recommendations as well.

Nowadays, it is quite common to use tumble dryers, where laundry dries evenly and does not crease much. This is done using electricity.

The most innovative way of drying clothes, however, is to use **clean solar and wind energy**, i.e. the good old washing line outdoors. Sun exposure causes many materials to lose colour. This can be prevented by turning laundry inside out. Other materials *(elastane, polyamide)* become more brittle in the sun and should be dried in the shade.

Sun-dried laundry has a distinctively pleasant fresh laundry scent. What causes it? Solar radiation triggers a photochemical reaction that produces various aldehydes and ketones from molecules in water, air and laundry fibres, and our nose associates these compounds with the smell of plants or perfume, and they are also present in many essential oils. Researchers found pentanal *(a compound found in cardamom)*, octanal *(with a citrus smell)*, nonanal *(with a rose-like smell)* and a dozen other pleasant-smelling compounds in dried laundry.

IRONING

Ironing, rolling, stretching and, increasingly, **steaming** are all different methods used to get wrinkles out of clothes if we are so inclined. Again, ensure that the temperature and working methods are suitable for the specific fabric. Many synthetic clothes never crease, and line drying utilises wind and a suspended position to help smooth out wrinkles.

THE ART OF MENDING

Everyone who wears clothes *(apart from babies, of course!)* and picks up a few basic tricks should be able to manage the most basic repairs or clothing first aid.

Sewing on a button is not too difficult and even stitching up a small hole is well within the capabilities of most people using a basic sewing kit. You could also cover holes with embroidery or a decoration. What was once a hole thus acquires an ornamental purpose and does not need to be hidden at all.

Decorative mending techniques, such as Japanese *sashiko* stitch mending, are all the rage.

Patching is an ancient mending technique and can be done at a very basic as well as very advanced level.

In 2022, a trouser-patching competition was organised in Estonia under the auspices of the Friends of the Heimtali Museum and the mended trousers were displayed in a special exhibition.

The Japanese patching technique of *kaketsugi* involves taking a patch of fabric from the same garment and incorporating it thread by thread into the garment so that the patch cannot be seen at all afterwards.

MENDING SHOPS AND ATELIERS

If the damage is more extensive *(a broken zipper, a bigger hole or tear, stubborn stains, etc.)* and you lack the tools or skills to do the repairs yourself, you can always turn to a mending shop or use professional mending services. You can also take in and let out clothes, redesign them, add embellishments and more.

99% of items can be repaired and redesigned.

A garment that has been upcycled and given extra wear time is provided with a "life story". Wearing a garment is the most rewarding time of its life cycle and the longer it can last, the better.

OUT OF THE CLOSET
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PHOTOS:
Dust: istockphoto/M-Production
Washing machine filter: istockphoto/Jae Young Ju
Care instruction: istockphoto/AndreyPopov
Washing line: istockphoto/Anastasiia Krivenok
Mending techniques (3 photos): Olev Kenk, ERR

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