MERIT BADGE SERIES

TEXTILE

BOY SCOUTS OF AMERICA®

BOY SCOUTS OF AMERICA
MERIT BADGE SERIES

TEXTILE

"Enhancing our youths' competitive edge through merit badges"

BOY SCOUTS OF AMERICA®

Requirements

1. Discuss with your merit badge counselor the importance of textiles. In your discussion, define the terms *fiber, fabric,* and *textile.* Give examples of textiles you use every day.
2. Do the following:
    a. Get swatches of two natural-fiber fabrics (100 percent cotton, linen, wool, or silk; no blends). Get swatches of two synthetic-fiber fabrics (nylon, polyester, acrylic, olefin, or spandex). Get a sample of one cellulosic fabric (rayon, acetate, or lyocell).
    b. Give the origin, major characteristics, and general content of each type of fiber obtained for 2(a). Explain the difference between a cellulosic manufactured fiber and a synthetic manufactured fiber.
    c. Describe the main steps in making raw fiber into yarn, and yarn into fabric.
    d. Assume you will soon buy a new garment or other textile item. Tell your counselor what fiber or blend of fibers you want the item to be, and give reasons for your choice.
3. Do TWO of the following:
    a. Visit a textile plant, textile products manufacturer, or textile school or college. Report on what you saw and learned.
    b. Weave a belt, headband, place mat, or wall hanging. Use a simple loom that you have made yourself.

35958
ISBN 978-0-8395-3344-3

2019 Printing

c. With a magnifying glass, examine a woven fabric, a nonwoven fabric, and a knitted fabric. Sketch what you see. Explain how the three constructions are different.

d. Make a piece of felt.

e. Make two natural dyes and use them to dye a garment or a piece of fabric.

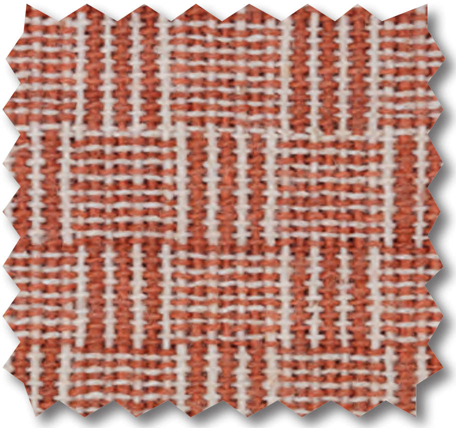
f. Waterproof a fabric.

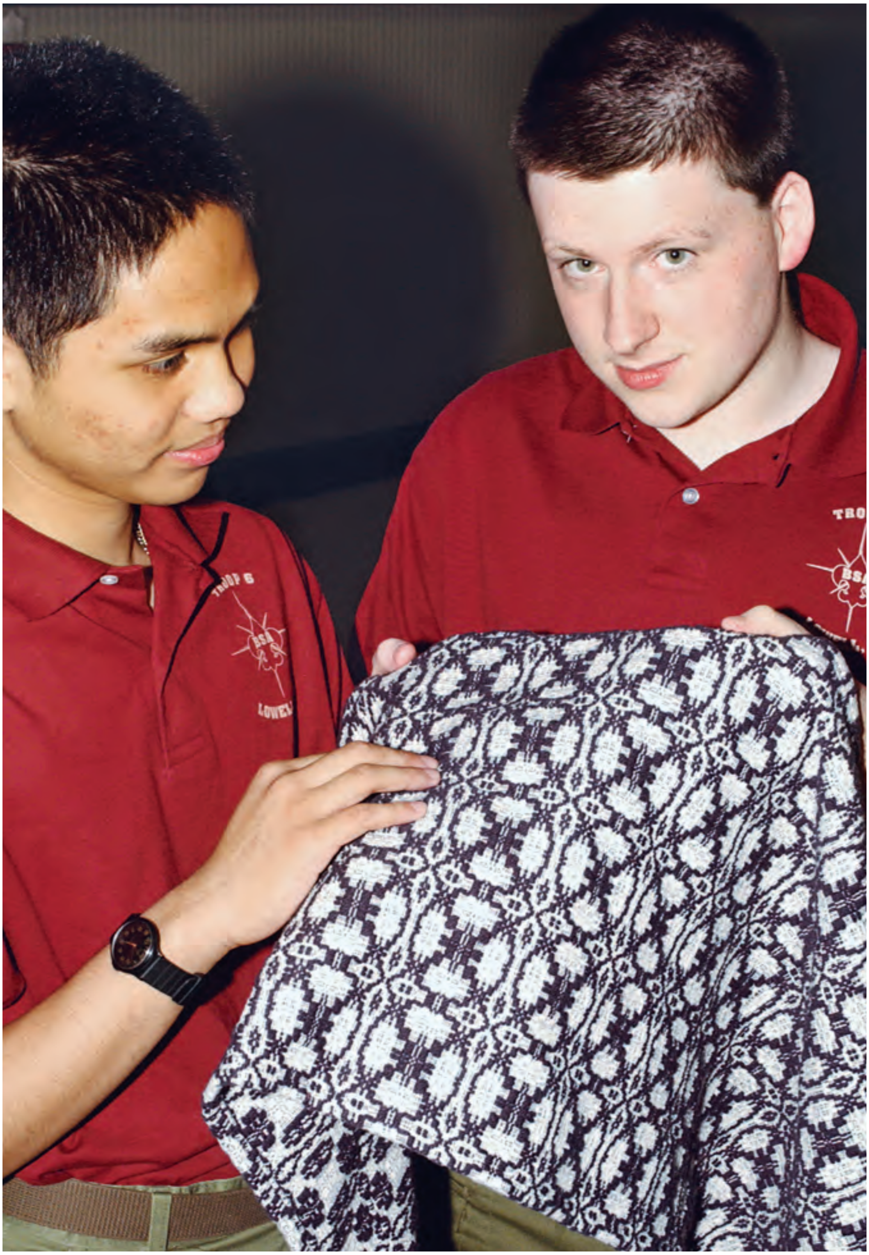
g. Demonstrate how to identify fibers, using microscope identification or the breaking test.

4. Explain the meaning of 10 of the following terms: warp, harness, heddle, shed, aramid, spandex, sliver, yarn, spindle, distaff, loom, cellulose, sericulture, extrusion, carbon fibers, spinneret, staple, worsted, nonwoven, greige goods.

5. List the advantages and disadvantages of natural plant fibers, natural animal fibers, cellulosic manufactured fibers, and synthetic manufactured fibers. Identify and discuss at least four ecological concerns regarding the production and care of textiles.

6. Explain to your merit badge counselor, either verbally or in a written report, five career possibilities in the textile industry. Tell about two positions that interest you the most and the education, cost of training, and specific duties those positions require.




BSA

Contents

21st Century Textiles 7

A Little Textile History 11

Natural Fibers 15

Manufactured Fibers 22

Spinning, Weaving, Knitting, and Bonding 27

Weaving Your Own Textiles 39

The Art of Fabrics 47

The Textile Detective 55

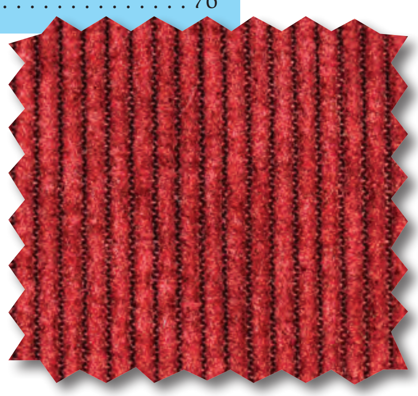
Looking Good: You and Your Clothes 58

Textiles and the Environment 63

Textiles, Tomorrow, and You 69

Glossary 72

Textile Resources 76




HOSE
C. DUKE

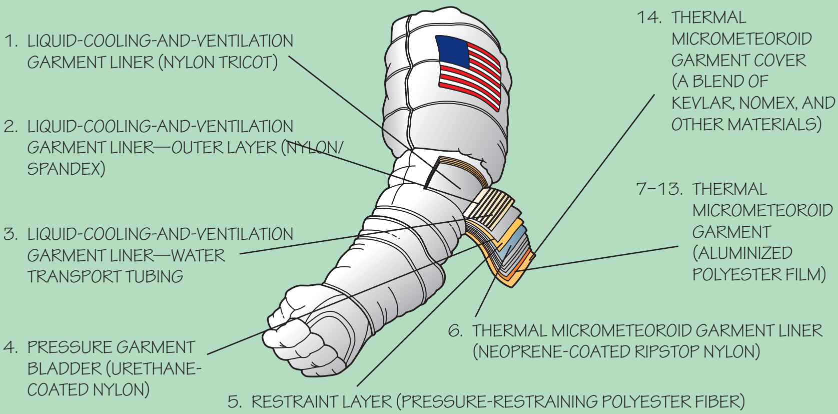
21st Century Textiles

Do you have a nylon windbreaker or raincoat? Do you pack a Mylar emergency blanket for hikes and campouts? Are any of your clothes made of polyester, in whole or in part? If you are not sure, look at the sewn-in label. Chances are you have shirts that are 65 percent cotton and 35 percent polyester, or a 50-50 blend of the two.

If you answered yes to any of these questions (and you probably did), then you are wearing some of the same fabrics that protect astronauts when they go on spacewalks.

Space-shuttle crews wear spacesuits made with 14 layers of fabric. Going from the inside out, there's nylon tricot, spandex, a lacing of plastic tubes, urethane-coated nylon, polyester fiber, ripstop nylon, seven layers of polyester film, and an outer layer made of fibers that are lighter and tougher than steel.

Those same stronger-than-steel fibers, called *aramid* fibers, are used to make bulletproof vests for police officers and flameproof suits for firefighters. One of the best-known aramids has the trade name Kevlar.



Nylon and spandex are also used in swimsuits and other kinds of athletic clothing. Nylon safety nets protect construction workers from falls. In the Arctic, the U.S. Army uses nylon fabrics to insulate shelters that keep the temperature inside at 50 degrees when the temperature outdoors drops to minus 65 degrees.

Fabrics also can be used to make buildings. The Denver International Airport terminal is a fabric building on a grand scale. Its roof is made of 15 acres of fabric. Two layers of woven fiberglass let sunlight in but resist dirt. The outer layer is coated with Teflon, making it waterproof and easy to clean. These are just some of the amazing ways in which fibers and fabrics are used today. The list could go on for pages.

The fabric roof of the Denver International Airport lets natural light in during the day.

- Surgeons replace diseased arteries with artificial arteries knitted or woven from fibers.
- Nylon, glass, and other high-tech fibers give strength to auto bodies and sports equipment.
- There are road-paving fabrics and erosion-control fabrics.
- Fibers are used in electronic circuit boards.
- Fibers are used in artificial turf for athletic fields, in tear-resistant mailing envelopes, and in attic insulation.
- In some buildings, combinations of textiles and plastics have replaced steel construction beams.

People use countless fibers and fabrics in their everyday lives: clothes, carpets, curtains, towels, bedsheets, upholstered furniture. Add to that list boat sails, bookbindings, bandages, flags, sleeping bags, mailbags, airbags, seat belts, backpacks, parachutes, umbrellas, basketball nets . . . Stop and look around you, and you are sure to see items this list missed.

High-Tech Textiles

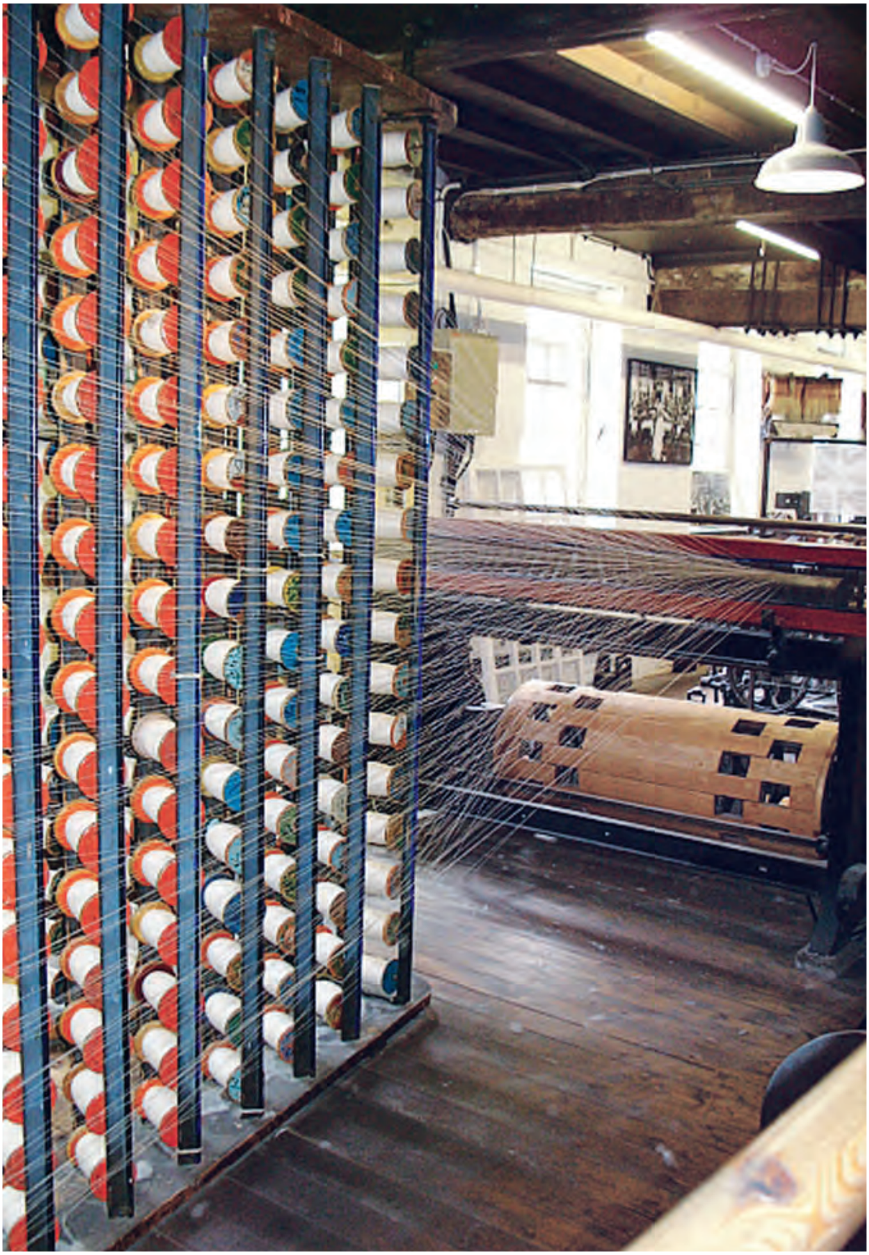
The textile industry is among the most thoroughly modern of all industries. For example, robots travel around yarn-spinning machines and automatically tie broken threads with no help from human hands. Computer-controlled knitting machines can be instantly programmed from a scanned photograph to knit the image that was scanned. Other machines and processes produce three-dimensional woven composites for such products as kayaks, canoes, and extreme sports gear.

Fiber, Fabric, Textile

What is the difference between a fiber and a fabric, or between a fabric and a textile? You will see these words many times in this pamphlet, so take a minute now to be sure you understand them.

- A *fiber* is the thin strand or *filament,* either natural or manufactured, that is formed into yarns and then used to make a fabric. For example, you might say, "This fabric is made from cotton fiber."
- Another word for *fabric* is "cloth" or "material." You would say, for example, "Good clothes for hiking may be made of wool, cotton, or synthetic fabrics." Fabrics are constructed from fibers.
- *Textile* generally means a woven fabric, but all types of fabrics are considered textiles, including knits, felts, laces, nets, and braids. In the textile industry, the fibers and yarns used to make fabrics are also referred to as "textiles." A textile can be a cloth or it can be a fiber, filament, or yarn used in making cloth. In short, anything made of fibers is a textile.

Many of the words people use to talk about textiles are centuries old. The word *yarn,* for instance, came into English so long ago that nobody can say exactly when it was first used. Other textile-related words are quite new. *Aramid* has been around only since 1961. The glossary near the end of this pamphlet will help you learn the special language of textiles.



A Little Textile History

We will never know who made the first thread or the first cloth, or where the idea came from. Perhaps some early humans saw how grass stalks and plant fibers could be rolled together to form strings that would not pull apart. Maybe they saw wild sheep shed their wool in spring, and they noticed how the wool would twist and mat into yarnlike strings. Maybe people got the idea from watching spiders weave webs or weaverbirds build nests.

We know that people learned to weave thousands of years ago. They wove grasses, leafstalks, palm leaves, and thin strips of wood, from which they made fishnets and baskets. Soon after, people combined the principles of basket weaving and twine making to create crude mats and, in time, finer and finer weaves.

Adventures in Fabrics

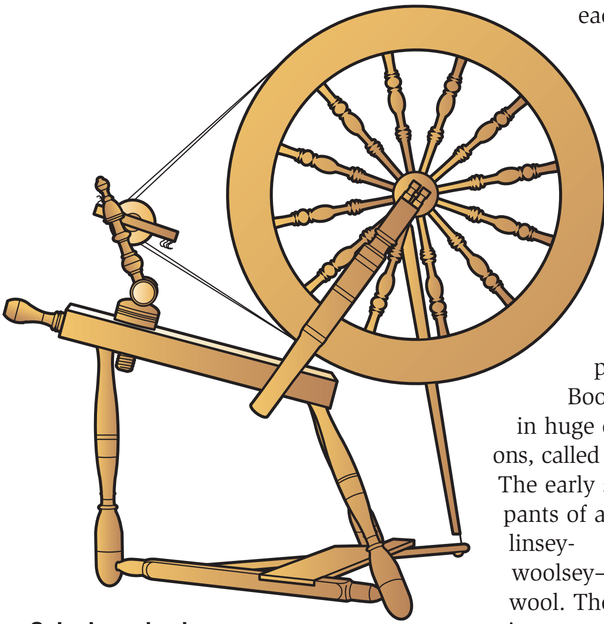
Textiles have long been a part of the American adventure. When Spanish explorers made their way inland from the coasts, they found the local people dressed in colorful garments woven of native cotton. In Mexico, the Spaniards faced Aztec fighters wearing padded cotton jackets as armor. All over the Americas, the native peoples knew how to weave beautiful cotton cloth.

America's native people, such as this Navajo woman's ancestors, were weaving beautiful fabrics long before Europeans began exploring the New World.

From the Spaniards, the peoples of the Americas learned about wool. For example, as Coronado and his bands of soldiers searched the Southwest in 1540, they left a few sheep in the villages they visited, and they taught the American Indians how to use wool as they used cotton for blankets, clothing, and shelter.

Cloth in the Colonies

In the northern colonies of New England and New Amsterdam, making fabrics was an important daily activity. In Massachusetts, a law required each family to produce a certain amount of cloth each month. The spinning wheel was a part of every colonial kitchen. Women worked every spare moment at the spinning wheel and loom.



Spinning wheel

In the wake of pathfinders like Daniel Boone, families went west in huge canvas-covered wagons, called "prairie schooners." The early settlers wore shirts and pants of an itchy fabric called linsey-woolsey—half linen and half wool. The soldiers on the frontier wore uniforms of wool.

In those days, cloth was precious, and not of a very high quality as compared with today's fabrics. Fine cloth and clothing were a sign of wealth and were often given as gifts by kings. The good fabrics came from England, where several textile machines had been invented, making it possible to make hundreds of times more fabric.

A Revolution

The fabric the English shipped to the colonies was a profitable source of income, so England was careful not to let the colonies develop their own textile industry. The English government passed laws forbidding Americans to raise sheep or make textiles. Eventually, these and other restrictions and taxes led to the American Revolution.

When the Revolutionary War was won and the former colonies became the United States, they still did not have a textile industry. The French and English were forbidden to leave their countries with textile machines, or the knowledge of how to make them.

Then along came Samuel Slater, who came to America after serving an apprenticeship in a textile mill in England. He knew how much the United States needed textile mills, so he memorized the construction of every piece of textile machinery used in a mill of the time. In 1789, he arrived in Rhode Island disguised as a farmer. Slater built a spinning machine and the other equipment needed to operate a mill.

The new spinning machines and power looms helped bring about America's industrial revolution, when power-driven machines replaced handwork.

At the same time that Slater was building his mill, a New England schoolteacher named Eli Whitney watched people on a Georgia plantation cleaning cotton by hand. After many experiments, he worked out a machine called a "cotton engine," or "cotton gin," which did the work of 50 laborers in picking seeds and debris out of the cotton fluff. His invention made growing cotton profitable in the South, and this made more raw material available to the mills in the North and in Europe.

With improvements in steam engines and the introduction of electricity, America's textile industry flourished. By the middle of the 19th century, textiles were the biggest industry in the country.

Natural Fibers

For most of human history, people could make fabric only from natural fibers from plants, animals, and minerals. The major natural fibers are cotton, flax, wool, and silk.

Cotton

Cotton grows in puffy masses from the surfaces of the seeds in the cotton plant pod or "boll." It is the most widely used of all plant fibers and is the world's main clothing fiber.

Varieties

Cotton grows in warm and hot climates all over the world and has played an important part in many civilizations. The ancient cultures in India may have been the first to grow cotton to make cloth, about 6,000 years ago. The Nile River delta in Egypt was also good for growing cotton, and the people of the pharaohs became highly skilled in cotton fabric making. The Egyptian varieties of cotton are still among the finest.

Sea Island is an American cotton first grown along the southeast Atlantic Coast. From it comes the finest and longest fiber of all the cotton types, used in making sewing thread and fabrics that imitate silk in their luster and quality.

Pima, named for the Pima Indians, is a cross of American Pima and Egyptian Sakel cottons. It is a creamy colored cotton grown in the southwestern United States.

Upland or American upland cotton makes up most of the world's cotton crop. The American colonists grew it inland, or "upland," from the Atlantic Coast, which is how it got its name. Upland cotton is not as long or as strong a fiber as Pima or Sea Island.

Flax

The fiber for linen comes from the inner stalk of the flax plant. Like the cotton fiber, flax is mainly a woody substance called *cellulose,* which forms a major part of the cell walls of trees, grasses, and many other plants. All fruits and vegetables contain cellulose, and cellulose fibers strengthen the stems, roots, and leaves of many kinds of plants.

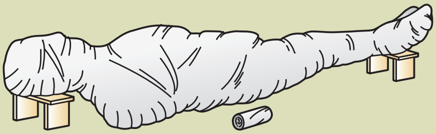
Linen is the strongest of the plant fibers.

Flax field

Linen's reputation for elegance and quality is due to the nature of the fiber. Flax is a long, smooth fiber, from 6 to 40 inches in length, which makes it possible to twist yarns with no fuzzy ends, leaving a crisp, clean surface. Flax also has a natural wax that helps give the finished linen a polish. Linen is ideal for tablecloths, dish towels, handkerchiefs, or any fabric in which strength is needed.

Linen traditionally is popular as a summer fabric because it can absorb and evaporate perspiration, which helps keep the wearer's body cool. It also can be washed and boiled without harm. Linen wrinkles easily but also presses easily.

Flax has been used since ancient times to make fabrics. The ancient Egyptians grew flax along the Nile about 7,000 years ago. Linen mummy wrappings from Egyptian tombs are still in good condition, and to this day linen fabrics have a reputation for durability, beauty, and luxury. Most of the world's flax is grown in Russia.



Preparing Flax Fibers

Flax harvested in late summer makes the best quality linen. The stalks are pulled out of the ground, tied into bundles, and dried in the sun. Then the stalks are soaked in water to decompose the outer stalk and make the inner fibers available for gathering. This process is called *retting*. The word resembles the English word "rotting" and actually is a kind of rotting or decomposing.

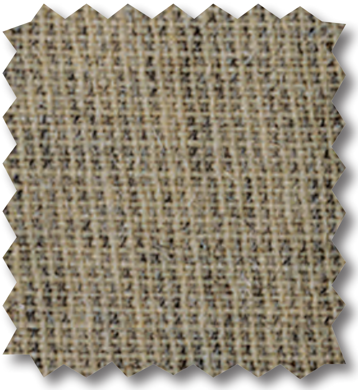
The retting can be done in different ways.

- In dew retting, the flax is spread out on the grass and left in the sun and rain for several weeks. Bacteria and moisture break down the tissue around the flax fibers. The fibers can then be separated from the stalk's woody bark.
- In water retting, which is more common, bundles of flax are soaked in tanks, pools, slow-moving rivers, streams, or bogs for a week or two, until they are ready for the separation processes.
- Chemical and mechanical retting is faster, but the chemicals and the mechanical rollers and crushers that hurry the retting process may weaken the flax fibers.

After retting, the flax is dried. The final steps in separating the flax fibers from the outer stalk are *breaking,* where the stalks are cut; *scutching,* where the pieces of bark are removed; and *hackling,* which is a combing process that straightens the flax fibers and separates the long from the short fibers. The long fibers, called *line,* are used for high-quality items such as fine tablecloths and clothing. The short, irregular fibers, called *tow,* are used for less-expensive items such as dish towels.

Jute, Hemp, and Ramie

Other plants have an inner fibrous growth, like flax, that can be separated and spun. *Jute* is a long, glossy fiber from a plant mainly grown in China, India, and Bangladesh. The most important use for jute is in the coarse bagging we call burlap. It is also valuable for twine and rope and as a backing on carpets.



Burlap

Ramie is one of the strongest natural fibers, and it is especially strong when wet. This "wet strength" and its natural resistance to mildew have made it historically popular for such items as ropes, twine, sails, and canvas.

Hemp fibers come from the hemp plant's woody stem and are used to make rope, cord, and twine. Hemp produces a strong fiber that can be more than 6 feet long. The fibers can be spun tightly and can withstand great weights before pulling apart or breaking.

Ramie is a fiber from an East Asian plant. It is also known as China grass and has been used since ancient times. Ramie is natural white in color, has a high luster, and is so similar to linen that, when used in fabrics, it is often mistaken for linen. It is absorbent, dries quickly, and is naturally resistant to bacteria and molds.

Wool

People have been using sheep's wool for at least 10,000 years. Early herders in central Asia found that sheep were easy to tame, stayed together, were not fussy about what they ate, and produced a stretchable, durable fiber that could be made into everything from clothes to blankets, rugs, and tents.

By 4000 B.C., people in Babylonia and Mesopotamia were wearing elegant clothes made of wool. Over the centuries and in all parts of the world, breeders have worked to improve sheep, trying to develop wool that would be best for different uses.

What Is Wool?

Wool is hair, an animal fiber made mostly of a tough protein called keratin. Keratin is found not only in wool and hair, but also in the nails, claws, and hooves of mammals; the scales of reptiles; and the feathers of birds.

Wool is very stretchable. A single fiber may be stretched to nearly twice its own length without breaking. This characteristic makes woolen fabrics comfortable. The warmth of woolens comes from the natural crimp or waviness of the wool fiber, which makes the yarn bulk up and spread a little, trapping air and creating an insulation layer. This same waviness that helps the fabric return to its original shape after wrinkling.

Other Wool-Bearing Animals

Some wool comes from animals other than sheep. These wool-bearing animals include the camel, alpaca, Angora goat, Cashmere goat, llama, and vicuña.

Camel. Camel's-hair coats are famous for their softness, durability, light weight, warmth, and natural tan color.

Alpaca. The alpaca lives in the Andes Mountains, and its wool is prized for its silky beauty and strength. The wool of the alpaca is stronger than sheep's wool and is about 6 to 12 inches long.

Angora goat. Angora goats were first domesticated in Turkey. The long, silky hair of the Angora goat is known as mohair. (The fiber called "Angora wool" is really the hair of the Angora rabbit.) Mohair is lustrous and has more resilience and bounce than sheep's wool. It is popular for men's summer-weight suits and in better grades of upholstery and draperies. Because of its unusual whiteness and luster, mohair can be dyed very bright shades.

Angora goat

Cashmere goat. The Cashmere goat is a native of the Himalayan Mountains. Soft fibers from its fine undercoat are spun into a spongy, woollike yarn. Cashmere is softer and lighter than wool but less durable. It is popular for sweaters, scarves, and shawls.

Llama. The llama is related to the camel but is about one-third as big. It is a beast of burden for the peoples of the high Andes and has hair with good insulation qualities. The hair of the llama is not as fine as that of its relatives the alpaca and vicuña, but it has more colors. This makes possible many beautiful tones when blended with the softer hair of its relatives.

Vicuña. The smallest and rarest of the llama family, the vicuña lives wild in almost unreachable mountain heights, where people ordinarily cannot survive without extra oxygen. A single vicuña yields only a quarter-pound of hair. It takes the hair of 40 animals to get enough fiber to make a topcoat. Not surprisingly, vicuña is among the most expensive fibers used in suits and coat fabrics.

Silk

If you have done any nature study on the life cycle of moths and butterflies, you know they go through an astonishing series of changes. At one stage, the caterpillar creates a casing or cocoon around itself. The caterpillar of the silk moth *(Bombyx mori)* squirts out a fine, continuous thread called a filament through a hole under its chin called the *spinneret.* With its head, the silkworm whips the filament around its body in a series of figure eights until it is enclosed.

In countries where silkworm production is important, silkworms are carefully raised on clean trays and fed a diet of young mulberry leaves. To produce a pound of silk fabric, silkworms must eat 200 pounds of leaves. In Japan, raising silkworms and "harvesting" the filaments has been a major industry for more than a thousand years. The origin of silk-making goes back thousands of years earlier to China.

Silk cocoons

Silk's Origin

According to legend, a Chinese empress discovered how a cocoon could become unwound when one fell out of a tree into her cup of tea. In the hot tea, the glue holding the filament together melted, and she could see the fine, threadlike mass. A little experimenting showed that this nearly endless fiber could be spun into fine yarn in much the same way as cotton. When woven, the lustrous yarn produced a wonderful cloth unlike any other. The nobility thought this new cloth was a gift from heaven and decided only princes and princesses could use it. Only the Chinese knew how to make silk textiles for about 3,000 years.

The making of silk was a closely held secret, but there were people ready to risk torture and death to take the secret to their own countries. Silk was carried to the Roman Empire by two monks who hid silkworm eggs in a hollow cane. By the 1200s, Italy was the major silk-weaving country of Europe.

When America was colonized, some people thought the New World might be perfect for *sericulture,* as the raising of silkworms is called. King James introduced it into the Virginia Colony, and Benjamin Franklin tried to encourage the industry during the Revolution, but the silkworm never did well in the North American climate.

Making Silk

Manufacturing silk begins with incubating the tiny eggs of the silkworm moth. After the eggs hatch, the larvae eat almost nonstop for six weeks. Then they start to spin their cocoons. Each caterpillar wraps itself in one continuous silk filament.

The finished cocoons are put in hot water to dissolve the gummy substance that holds the silk filament together. When the silk is loosened, the filaments from four to eight cocoons are joined and twisted. They are then combined with several other similarly twisted filaments to make a thread. The resulting thread, called raw silk, is made up usually of 48 individual silk fibers. The thread is continuous and, unlike the threads spun from other fibers such as cotton and wool, is made up of extremely long fibers.

Mineral Fibers

In addition to fibers from plants and animals, there are two important mineral sources of natural fibers—asbestos and glass.

Asbestos is a hard mineral with an unusual threadlike makeup. The rocklike mineral can be crushed and the fibers gathered to make yarn and then cloth. Asbestos will not burn, so it is valuable in insulation and other building materials. Breathing asbestos fibers, however, can cause serious lung diseases and cancer. In the United States, government regulations ban any product that could release asbestos fibers into the air.

The raw material of *glass* fiber is quartz sand, much like that found at the beach. Melted glass can be stretched and drawn out to thread-thin filaments and spun into yarn. Fabrics woven from glass yarns are fireproof and cannot be damaged by sunlight, moths, or chemicals in the air.

Manufactured Fibers

In 1664, English scientist Robert Hooke suggested it might be possible to make a fiber that would be "if not fully as good, nay better" than silk. But the first patent for "artificial silk" was not granted until 1855, to a Swiss chemist named Audemars. Audemars dissolved the fibrous inner bark of a mulberry tree and got liquid cellulose. He made threads of it by dipping needles into the liquid and drawing them out.

Microfiber Facts

Microfibers have been around since the late 1980s. Depending upon how it is processed or "spun," this amazing synthetic fabric can have excellent breathing and wicking ability, be resistant to wrinkling and abrasion, and be wind- and water-resistant and quick-drying, making it a good choice for active wear and outerwear.

Rayon

In 1889, French chemist Hilaire de Chardonnet caused a sensation in Paris with the light, smooth, lustrous fabrics he made from artificial silk—a fiber we now know as *rayon*. In the United States, no attempt to produce artificial silk from cellulose was commercially successful until 1910.

Acetate

In 1893, Arthur Little of Boston invented another substance made from cellulose, called *acetate*. It originally was used to make film and lacquer to stiffen the wing fabrics of airplanes. By 1921, the spinning technique developed to make acetate fibers allowed acetate to be knit and woven into cloth.

Nylon

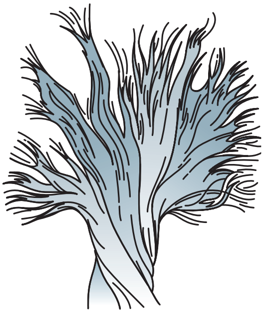
In 1931 American chemist Wallace H. Carothers told the world about a new fiber he called "66." It was later named *nylon* and nicknamed the "miracle fiber." Nylon was made from petrochemicals, which are found in petroleum and natural gas.

The first experiments used nylon as sewing thread, in parachute fabric, and in women's hosiery. But in December 1941, the United States entered World War II and every bit of nylon was needed for parachutes, tires, tents, ropes, ponchos, and other military supplies. It was even used for a high-grade paper for U.S. money.

After the war, the demand for nylon stockings was so enormous that almost all nylon was made into hosiery. By the end of the 1940s, nylon also was being used in carpets and automobile seats.

Olefin, Acrylic, and Polyester

Another synthetic fiber that is especially good for carpets and upholstery is *olefin,* which dates from 1949. Olefin fibers are strong and resist stains, which makes it useful in artificial turf for athletic fields. A strong, dense olefin fiber has been developed that is 10 times stronger than steel and used to reinforce hoses and power belts, and in athletic and automotive equipment. Olefin and acrylic sandbags are used as highway crash



barriers and on levees to prevent flooding. Olefin is lightweight and will float in water, making it ideal for such items as life rafts, life preservers, and marine ropes.

Acrylic, a wool-like manufactured fiber, came into use in the 1950s. The phrase "wash and wear" was coined to describe a new blend of cotton and acrylic that needed little or no ironing after laundering. Acrylic is highly resistant to ultraviolet light, so it finds many uses in such products as awnings, canopies, and outdoor furniture.

Another fiber that made the 1950s' wash-and-wear list was *polyester.* Clothes made with polyester were wrinkle-resistant and quick-drying. Polyester became the most widely sold manufactured fiber, used not only in clothes but also in bedspreads, sheets, pillows, curtains, furniture, carpets, tires, belts, hoses, backpacks, luggage, airbags, and high-performance fabrics used by athletes and the military. Insulating polyester fiberfill—put to the test by climbers on Mount Everest—is used in sleeping bags, parkas, and other cold-weather gear.

Spandex, Aramids, and Carbon Fibers

Super-strong *aramids* and super-stretchy *spandex* were introduced in the 1960s. The name "spandex" comes from the word "expands"—just rearrange the letters. The U.S. space program became a major user of special new fibers, for everything from astronauts' clothes to spaceship nose cones. When Neil Armstrong set foot on the moon on July 20, 1969, his lunar spacesuit included multiple layers of nylon and aramid fabrics, an early version of the suits worn by shuttle astronauts 30 years later.

The fire-protective fabric used to make firefighter uniforms is the same material used in gear worn by race car drivers, an aramid fiber called Nomex®.

Aramid fibers are increasingly being used as replacements for steel, fiberglass, asbestos, and aluminum. Yachts use strong, fast sails of aramid fibers. Skis with aramid-fiber cores last longer and perform better. Racing drivers wear aramid suits that help prevent them from burning to death in fiery, high-speed crashes.

Carbon fibers are extremely strong, stiff, lightweight fibers of nearly pure carbon made by "baking" or "charring" rayon, pitch, or acrylic fibers at high temperatures. They are used to strengthen airplanes and spacecraft. The exhaust nozzles of the two large booster rockets that lift the space shuttle into orbit contain 30,000 pounds of carbonized (charred) rayon. Three-dimensional fabrics made from carbon fibers may someday replace steel in such products as automobiles, military vehicles, and building structures.

Lyocell

Lyocell, first produced in the United States in 1992, is a relative of rayon. Like rayon, it is a cellulose fiber. It is soft, absorbent, and easy to dye. Unlike rayon, it is wrinkle-free. When the proper finish is applied, lyocell can be safely laundered at home and resists shrinking.

Lyocell yarns have an especially soft and luxurious touch that make this fabric popular for jeans, shirts, and other garments.

How Manufactured Fibers Are Made

There are two types of manufactured fibers:

- *Cellulosic* fibers are made from the cellulose in trees or other plants. Rayon, acetate, and lyocell are the main cellulosic manufactured fibers.
- *Synthetic* fibers come from chemicals made from refined petroleum or natural gas. The main synthetic fibers are polyester, nylon, acrylic, olefin, and spandex.

Most manufactured fibers are created by forcing a thick, gummy liquid (about like cold honey) through the tiny holes of a nozzle-like device called a *spinneret.* The spinnerets that are used to make most manufactured fibers are similar to a bathroom shower head. A spinneret may have from one to several hundred tiny openings. The liquid comes out of the holes in long, slender, soft strings that quickly harden. Fiber properties can be engineered by changing the shape of the holes to achieve different effects.

Spinning, Weaving, Knitting, and Bonding

Most textiles are made by twisting fibers into yarns and then weaving or knitting the yarns into fabrics.

- Twisting fibers together to make threads or yarns is called *spinning.*
- Crossing threads or yarns over and under each other to form fabrics is *weaving.*
- Looping and interlocking yarns is *knitting.*

Textiles are also made by bonding fibers together to form fabrics that are neither woven nor knitted. Such fabrics are known as *nonwovens.*

Spinning

Most fibers have what is called a *staple* length, which is their usual or average length. Short-staple cotton, for instance, has fibers typically ranging from .5 to 1.25 inches long. Long-staple cotton fibers are about 1.5 to 2 inches long. Manufactured fibers can be made in unbroken, almost endless filaments. But many of them are cut into staple lengths for blending with cotton or other staple fibers. In the process of spinning, these individual short fibers are twisted into a strong, continuous yarn of a workable length.

Hand Spinning

Around 8,000 to 10,000 years ago, people discovered how to put the clinging characteristic of wool and cotton fibers to work for them. Their basic tools were the *spindle* and the *distaff.* You can see pictures of these tools in the art of ancient Egypt. And if you visit the Navajo in the southwestern United States, you will still see this yarn-making system.

After carding, an extra step called *combing* may be done to further straighten the fibers and get them all lying in the same direction. Combed fibers make higher quality yarns for items such as combed percale sheets. But many yarns are only carded, not combed.

The ancient hand process of spinning yarn went like this: The spinner tied a clump of wool, cotton, or flax fibers on the end of a stick—the distaff. This stick was tucked under one arm to leave the hands free. The spinner pulled at the clump of fiber, drawing (drafting) a little of it off the distaff, and twisted the fibers roughly into a stringlike mass. This loose string was attached to the weighted spindle. As the spinner twisted the fiber, it caused the spindle to turn, too. The turning of the spindle further tightened the yarn to a firm, threadlike thickness ready to use in weaving.

Machine Spinning

The steps hand-spinners go through in preparing wool, cotton, or flax are still used. But in textile mills today, the steps are done by machines that speed up the processes tremendously and make many times more yarn.

Step 1—Opening and Blending. Compressed masses of raw fiber, such as baled cotton fiber, are *opened* (loosened) to separate and fluff the fibers. The fibers are blended, and in the case of cotton, they are also cleaned. The loose fibers are then blown through ducts to the next process, carding.

Step 2—Carding. The fibers pass over giant drums or rollers that are covered with wire teeth. The teeth untangle the fibers. This untangling process is called *carding.* Carding produces a web of fibers lying in random directions. The web of carded fibers is gathered into a soft, untwisted, rope-like strand called a *sliver* (SLY-vuhr). A sliver is usually about the size of a broomstick.

Carding

Step 3—Drawing. Several slivers are fed together into machines called draw frames. The draw frames draw or pull the slivers together to further straighten and blend the fibers and make them more uniform.

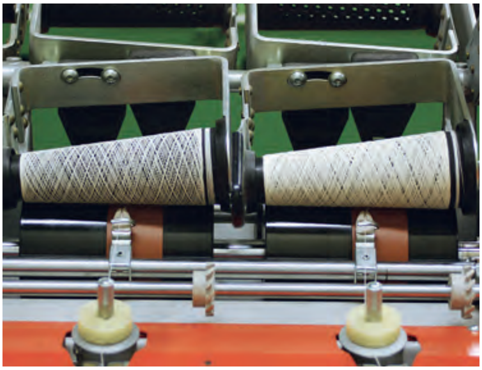
Step 4—Roving. In the process called *roving,* the slivers are pulled out (drafted) even more thinly and then gently twisted.

Step 5—Spinning. The roving is drawn out and given more twist, becoming tighter, thinner, stronger, and more even, until the yarn reaches the thickness or *count* (weight per unit of length) that is needed for the knitting or weaving of the fabric.

Step 6—Winding. Yarns are tightly wrapped around *bobbins* or tubes and are ready for weaving or knitting. Sometimes, if an even sturdier yarn is needed, two or three of the yarns are twisted together in *plies,* usually referred to as two-ply or three-ply. Unravel a piece of string to see how yarns are plied to make them stronger.

Roving

Spinning



Winding

Is It Woolen or Worsted?

Buying a wool suit or sport coat can be confusing if the salesperson starts talking about "woolens" and "worsteds." These are two basic wool fabric types. The difference is essentially in the spinning of the wool yarn before weaving. *Worsted* yarn, mainly used in suit and slack fabrics with a tight weave and smooth surface, is a combed yarn. Woolen yarn is only carded, not combed. *Woolen* yarn is not twisted as much as worsted yarn and is therefore softer, fuzzier, and thicker. The cloth made from woolen yarn is naturally softer and bulkier. Woolens, as you would expect, are what you usually find in soft, wool sport jackets and sporty winter coats.

Weaving

The weaving process is basically a crisscrossing or interlacing of straight yarns. Weaving is done on a *loom,* a rectangular open frame that is fitted lengthwise with yarns called the *warp.* Warp yarns are usually strong yarns, since they form the base or "skeleton" of the fabric.

The crosswise *filling* or fill yarns (also called *weft* yarns or *picks*) are worked in and out at right angles between the warp yarns. Traditionally, weavers used a pointed, boat-shaped *shuttle* to draw the fill yarn over and under the warp yarns. Faster methods are used today. Each row of fill yarn is a *pick.* The number of picks per inch indicates the fineness and weight of the fabric.

As each fill yarn is drawn through, it is pushed firmly against the previously inserted fill yarn. This process continues until the desired length of fabric is woven.

In an industrial setup, the strong warp yarns that will form the skeleton of the fabric are often covered by a protective film. This process, called *sizing* or *slashing,* makes the yarns stiffer and easier to handle when they are attached to the loom. These warp yarns are wound on a warp beam and placed at the back of the loom. Each warp yarn is then passed through a vertical *harness.* The number of harnesses depends on the complexity of the weave. In the harnesses, each warp yarn is threaded through a *heddle.* The heddles hold the individual yarns in place and keep them from tangling.

In every weaving process, after the warp yarns are in place, the following four basic steps are repeated, in this order and row by row, until the fabric is completed.


Modern automated loom


Hand loom

Step 1—Shedding. *Shedding* means raising some of the warp yarns by means of the harnesses, leaving others below. When the weaver (or weaving machine) lifts the harness that holds (for instance) the odd-numbered warp yarns, a space called the *shed* is created. The fill yarn will pass through the shed.

Step 2—Picking. Passing the fill yarn into the shed at right angles is called *picking.* This step places the fill yarn over and under the warp yarns.

Step 3—Beating up. To *beat up* means to push the fill yarn firmly against the yarn that preceded it, using a comblike device called a *reed.* The weaver (or weaving machine) levels the harnesses and, with the reed, pushes the newly woven pick compactly into place to tighten the weave.

Step 4—Taking up and letting off. As the weaving proceeds pick by pick, the finished cloth is turned or wound onto a bar called the cloth beam, or apron beam, at the front of the loom, and more warp is brought on from the warp beam.

Swifter Than a Shuttle

Modern looms can insert picks at speeds up to 300 to 400 feet per second.

The reed and harnesses on today's looms move much faster than the eye can follow. Modern looms weave without using shuttles. On a rapier loom, a mechanical arm called a rapier grabs the yarn and passes it on to a second rapier at the middle of the shed. In a projectile loom, a bulletlike projectile grips the yarn and shoots it through the shed. Jet looms use tiny jets of air or water to blow or propel the filling through the shed.

Air- and waterjet machines are the fastest methods of weaving today. They can insert up to 1,400 filling yarns per minute, and one new machine can insert four filling yarns at a time and weave 3,000 picks per minute.

Kinds of Weaves

What the weave will look like as it comes from the loom depends on the way in which the harnesses lift groups of the warp yarns to let the fill yarns slip through. In complicated weaves there may be up to 30 harnesses, but for the simplest constructions only two harnesses are needed.

Plain weave

Plain weave. The plain weave is a simple interlacing of warp and fill and is the weave used by makers of basic fabrics, either on hand looms or in mills.

Basket weave. The basket weave is a variation of the plain weave, but instead of one warp and one fill yarn, it has two or more warp yarns and two or more fill yarns, which adds a fuller, bulkier texture to the fabric. Oxford shirting is an example.

Twill weave. The visible, diagonal line that runs through fabrics like denim is a twill weave. The weave pattern forms a stair-step look. In popular *herringbone* pattern in wool sport jackets is also a twill weave. Twill construction is used in work clothes and uniforms where durability is needed.

Satin weave. The satin weave is similar to the twill weave, but the diagonal line is hidden so that the surface of the fabric is smooth and polished. The sheen and graceful drape of satin-weave fabrics make them popular for formal clothes, in damask for table linen, and for fine draperies. Satin-weave fabrics may snag easily.

Pile weave. Terry-cloth towels, corduroy pants, plush toys, and rugs can all be examples of pile-weave construction. Essentially, pile weave is like plain or twill weave with one added step: an extra warp or fill yarn is added and lifted above the surface to form loops. These loops can be left as is. Bath towels are an example. Or the loops can be snipped off, which allows the yarn ends to unravel a little, causing a soft surface.

Geometric and fancy weaves. Shirts with a tiny geometric pattern woven into the fabric, called "dobby fancies," were popular in 1910 and then 60 years later in 1970. They are made on the *dobby loom,* which can raise or lower the warp yarns in many more variations than are possible with simpler looms.

Corduroy is an example of a cut-pile fabric. If the loops are very long, you get plush or a fabric that may look like fur.

The Jacquard Loom

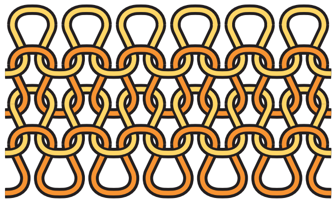
In 1801, French inventor Joseph Marie Jacquard created a loom that used punched cards to direct the weaving process. Jacquard "programmed" a design by cutting holes in a roll of paper. This roll was connected to a series of needles controlling the loom mechanism that moves the warp yarns up and down. When the needles hit a hole in the paper, it made a change in the way the yarns were woven. By changing cards and alternating the patterns of punched holes, it was possible to mechanically create complex woven patterns.

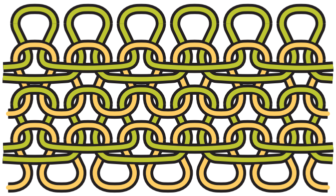
Modern Jacquard looms use electronic mechanisms for controlling the weave design. New designs can be quickly downloaded to the loom from a computer.

Jacquard

Knitting

Knitting is the process of making fabric by intermeshing loops of yarn. In hand knitting, two long steel or plastic needles are used. When the process is mechanized, multiple needles are arranged, either in a straight line or in a circle, to rapidly form loops of yarn into fabrics. The needle hooks grab the yarn and loop it through, quickly creating a flexible fabric. Depending on the tightness or looseness of the knit and the thickness of the yarn, the knitting process can be used to make the thinnest nylon stockings or the heaviest cable-stitch sweaters.





Knits are stretchable. They move with the body and are comfortable. Knits make warm outerwear because of the air spaces created by the loops of heavy yarn. The same porous quality also helps the fabric "breathe" in the light constructions used for sheer summer-weight knits.

Knitting Machines

There are two basic knitting machines.

The automated flat knitting machine has dozens of needles arranged in a straight line and can make more than a million stitches a minute. The flat needle bed produces a flat fabric like that made on a loom. The machine can be programmed to shape the fabric by adding or dropping out stitches. Two shaped pieces can be sewn together, as for the front and back of a sweater. Or a whole garment or stockings can be made in one piece by dropping loops of yarn at strategic points and in that way tapering the item. This construction is called *full-fashioned* and usually commands a high price because it represents quality workmanship.

Homemade flat knitter

The circular knitting machine has its needles placed in a circle around a drum. The machine revolves, and the needles knit a cloth that comes out the bottom as a tube of fabric. The simplest circular knitting machines have only one set of needles, called cylinder needles, which work up and down. Fabrics made on these machines are called "single-knit" fabrics. T-shirts are made on this kind of machine. An undershirt is made with the same plain knit stitch often used in hand knitting. Technically, circular knitting is a type of *weft knitting.* Weft knits stretch more from side to side than up and down, so they are popular in underwear and other light, pullover-type shirts.

Double Knits

Double-knit fabric is made with machines using two sets of needles, called dial and cylinder needles. The cylinder needles knit loops on the face of the fabric, while the dial needles knit loops on the back of the fabric. Using this knit and texturized synthetic fibers such as polyester, manufacturers make a firm yet flexible fabric that can be cut and sewn like woven fabric.

Warp knitting is the other basic type of knitting and differs from weft knitting in producing a fabric that is firmly held together in all directions, having what the experts call "dimensional stability." This overall balanced strength makes warp knitting popular for any item that has stresses placed on it from all directions—from hairnets to rugs.

Tricot knits are an important kind of warp construction, as are *raschel knits.* Tricot knits are lightweight; raschel knits are heavier. Raschel machines can knit any kind of fiber, including metal and glass yarns. Raschel knits are used for a variety of products, including blankets, men's suits, and swimwear.

Nets and Braids

Nets, which are called "open-mesh" fabrics, have wide spaces between the yarns. These fabrics can be made on some kinds of knitting machines. Netting is used for fishing nets, hammocks, and tennis nets.

Braids are made from three or more interlaced yarns. Braided fabrics are used for narrow items like shoelaces.

The nonwoven industry is one of the fastest growing industries in the world. The production of nonwovens amounts to about 20 percent of the total production of textiles, and that percentage grows year by year.

Felt and Other Nonwoven Fabrics

Take a good look at a piece of felt. You will see no sign of woven or knitted construction in it, because felt is a *nonwoven* fabric. It is made by pressing fibers of wool, fur, or animal hair together, creating sheets that can be cut and sewn like cloth.

For hundreds of years, the basic nonwoven fabric was felt. Today, many nonwovens are made from manufactured fibers such as polyester, rayon, and aramids. The individual fibers may be melted and fused together, stitched into place, stuck together with adhesives, or tangled together by means of hooked needles. Water jets and lasers are also being used to make nonwovens that look and feel like traditionally woven and knitted fabrics. The process is much faster and less costly than weaving or knitting.

Nonwovens are often used for disposable items such as place mats, napkins, fabric softener sheets, dust cloths, eyeglass lens tissues, tea bags, vacuum cleaner bags, bandages, and surgical gowns and masks. You will also find nonwovens used in automobiles for such things as dash insulators, hood silencer pads, and transmission oil filters. At home and school you will find nonwovens in book covers, pennants, blankets, and tennis balls.

Making Felt

You can make felt at home with a few simple items.

To make felt:

Step 1—Comb the wool fleece to make the strands lie straight and parallel.

Step 2—Put one cotton rectangle in the bottom of the dishpan. On the cotton, place a layer of wool fibers so that the fibers are parallel to the long side of the dishpan. Put another layer of wool on top of the first, but with the fibers parallel to the short side of the pan. Build up alternating layers of fibers, as many layers as you wish. The more layers, the thicker the felt you will make. Top the stack with the second cotton rectangle.

Materials Needed

- ☐ Wool fleece
- ☐ Comb
- ☐ Two rectangles of plain cotton fabric
- ☐ Plastic dishpan
- ☐ Soap flakes
- ☐ Spoon
- ☐ Hot water

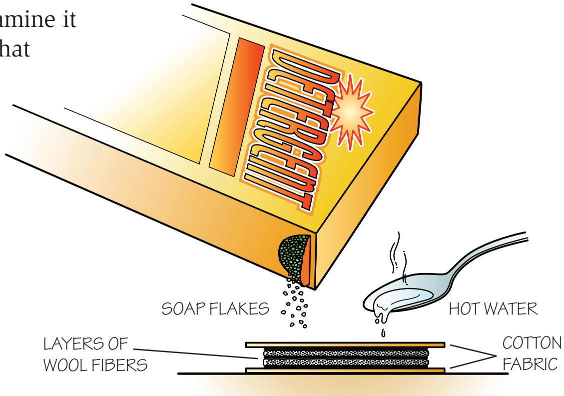
Step 3—Sprinkle soap flakes on top. Then carefully spoon hot water onto the "sandwich" to dampen the cotton and wool with just enough water to make it soggy. The water should be hot but not scalding. If it is too hot to handle, allow the stack to cool to a safe temperature before doing step 4.

Step 4—With your hands, rub the sandwich. Rub hard and keep rubbing. If you stop too soon, the soap and hot water will not have opened the scales of the wool enough for them to catch on each other, and your felt will fall apart.

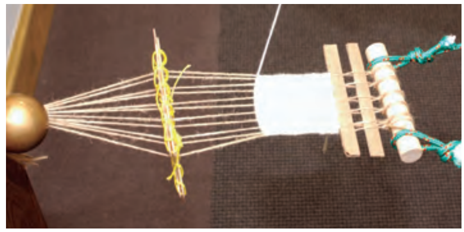
Step 5—Rinse the sandwich thoroughly, under running water, to flush out all of the soap. Peel off the cotton fabric. Allow the felt to dry.

When the felt is dry, examine it under a magnifying glass. What has happened to the wool fibers you combed straight?

What has this activity taught you about the dangers of machine washing and tumble drying a wool sweater? Has anybody in your family ever made that mistake and accidentally felted a good sweater?



Weaving Your Own Textiles



Many books on crafts show how to make simple looms such as those traditionally used by American Indians. Here is a simple, Indian-styled backstrap loom you can make. On it you can weave a belt, coaster place mat, or similar item.

Backstrap Loom

Materials Needed

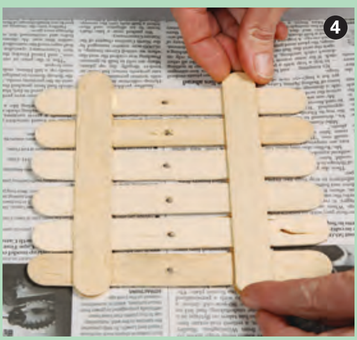
- ☐ 10 ice-cream sticks or tongue depressors
- ☐ Hand drill
- ☐ Newspaper
- ☐ Wood glue
- ☐ Cord
- ☐ Wood stick about 1 inch thick and 6 inches long
- ☐ Rope long enough to fit around your waist
- ☐ Carpet warp or string for warp threads
- ☐ Knife or coping saw
- ☐ Cardboard
- ☐ Thick yarn scraps for filling threads

To make the loom:

Step 1—Drill a small hole in the center of six ice-cream sticks or tongue depressors.

Step 2—Place two undrilled sticks on a piece of newspaper, in position for the crosspieces of the heddle.

Step 3—Spread glue on the two crosspieces. Lay the six sticks with holes across the two crosspieces, leaving enough space between the sticks for a warp thread to pass between them.



Step 4—Glue the last two sticks across the six sticks, facing the first two cross-sticks. Now you have a heddle. Place something heavy on it and let the heddle dry.

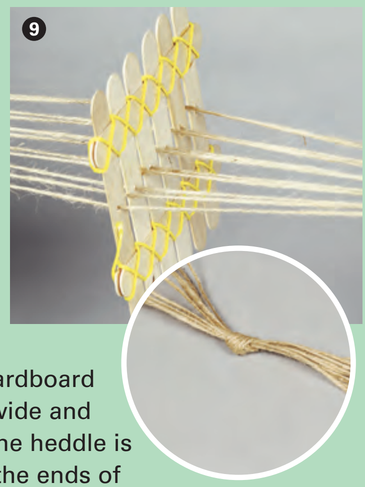
Step 5—When the glue has dried, secure the sticks with cord as shown.

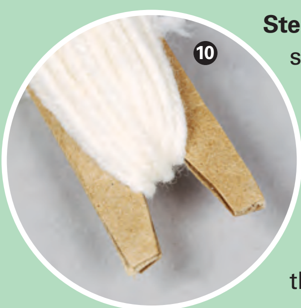
Step 6—Near each end of the 6-inch-long stick, whittle a notch around the stick. Tie one end of the rope around one notch. Put the stick in front of your stomach and bring the rope around in back of you and to the front. Make a loop in this end to slip over the other notch.

Step 7—Cut warp threads from carpet warp or string. Cut one warp thread the length of your project plus 18 inches, and cut five more warp threads twice as long.

Step 8—Tie the first warp thread to the 6-inch stick with a square knot. Fold the other warp threads in half. Wrap the fold loop of each folded thread around the stick. Pull both ends through the loop.

Step 9—Thread the first warp thread through the hole in the first stick of the heddle. Pass the second warp thread between the first and second sticks. Thread the third warp through the hole in the second stick. Pass the fourth warp between the second and third sticks. Continue in this way until all 11 warps are threaded. Tie all the ends together with an overhand knot.





Step 10—Cut a shuttle out of cardboard about 1 inch wide and longer than the heddle is wide. Notch the ends of the shuttle. Wind a thick filling thread around the shuttle. If you want different colors in the project, use several different-colored filling threads, each on its own shuttle.

Step 11—Cut two strips of cardboard ½ inch wide and as long as the heddle.

To weave:

Step 1—Fasten the knot of warps to a chair, hook, or tree.

Step 2—Fasten the rope around your waist.

Step 3—Start weaving close to your body. First weave in the two pieces of cardboard. To do this, raise the heddle. The warp threads will form the opening called the shed. Put one of the cardboard strips in the shed. Lower the heddle. This will make a second shed. Put the second cardboard strip in there.

Step 4—To start the yarn, raise the heddle with your left hand and pass the shuttle through, from right to left, with your right hand. The yarn will lay between the warps. Hold the heddle with your right hand, and with your left hand pass the shuttle around the last warp thread. With the heddle still raised, pass the shuttle back, from left to right. The yarn comes back between the same warps and is anchored. Every time you start a new color or put more yarn on your shuttle, start and finish your yarn this way.

Step 5—Begin weaving by dropping the heddle and passing the shuttle through, from right to left, from your right hand to your left hand. Raise the heddle with your right hand and pass the shuttle back with your left hand. "Beat" or push the filling yarn together. Continue to do this for the length of your belt. After you weave 5 or 6 inches, wrap the weaving around the stick at your waist so you can weave easily. Do not pull your weaving too tight. Keep the edges straight and even.

Step 6—Cut the ends of the warp threads tied to the stick. Remove the cardboard strips and knot the warp threads together with a square knot. Pull the knot up tight against the weaving to keep it from unraveling. Cut and knot the other end the same way.

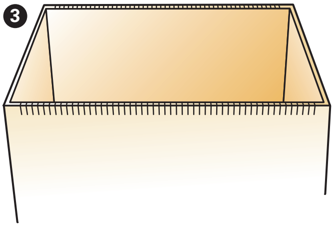
Box Loom

You also could make a box loom to weave a wall hanging, place mat, or small rug.

To make the loom:

Step 1—Use a sturdy cardboard box about 12 inches wide, 14 to 18 inches deep, and 10 inches high. A letter/legal-size cardboard storage carton with a lift-off lid works well. A shoe box will not be large or strong enough.

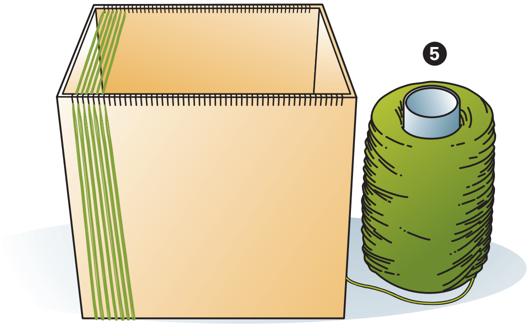
Step 2—If the box has flaps, cut them off the top. If the box has a removable lid, lift it off.



Step 3—Using ruler and pencil, make a mark every ¼ inch along the top edge of one short side of the box. Do the same on the other short side of the box.

Step 4—Cut a slit ¼ inch to ½ inch deep at each of the marks.

Step 5—Use a long, strong yarn for the warp threads. Tape one end of the yarn to the box. Then begin to wrap the yarn around the box, inserting it into each slit at the top of the box edge as you go. Wrap the yarn completely around the box and continue until you have filled every slit. Keep an even tension on the yarn but be careful not to pull it so tight that you bend the sides of the box loom. When you have finished threading the loom, tape the tail end of the yarn to the box.

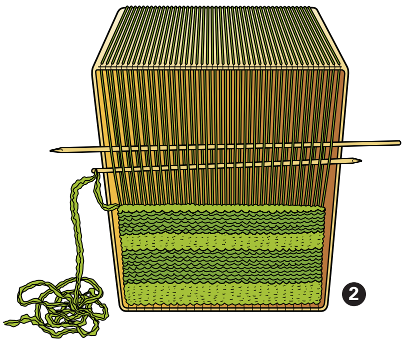


Materials Needed

- ☐ Sturdy cardboard box
- ☐ Scissors or knife
- ☐ Ruler
- ☐ Pencil
- ☐ Strong yarn
- ☐ Adhesive tape
- ☐ Thick, fluffy, or textured yarns
- ☐ Knitting needle or ¼-inch dowel
- ☐ Weaving needle or ¼-inch dowel
- ☐ Fork

To weave:

First weave a header. The header helps align the warp threads properly, lets you check for mistakes made in threading the loom, and gives a firm edge for beating the weft into place. You can use any type of scrap yarn for the header because you will remove it when the project is finished, but try to use a yarn similar in weight to the yarn you will use in the finished piece.



To weave the header:

Step 1—Use a knitting needle or a ¼-inch dowel rod (sharpened to a dull point at one end and sanded smooth) to pick up the warp threads. To make a plain weave, pick up every other warp thread so the weft will travel over and under each thread.

Step 2—Rest the knitting needle or dowel on the edges of the box to hold the raised threads in place. Using a weaving needle or a second dowel rod as a shuttle, draw the weft thread through the open shed. To turn a ¼-inch dowel rod into a shuttle, whittle a notch near one end and tie the weft thread to the notch. Sharpen the other end to a rounded point.

Step 3—Slide the knitting needle or first dowel rod out from between the warp threads.

Step 4—For the next row, use the knitting needle or dowel to pick up the other warp threads (the ones not raised for the first row). Weave the weft thread back across.

Step 5—Repeat until you have woven a header three or four yarns wide.

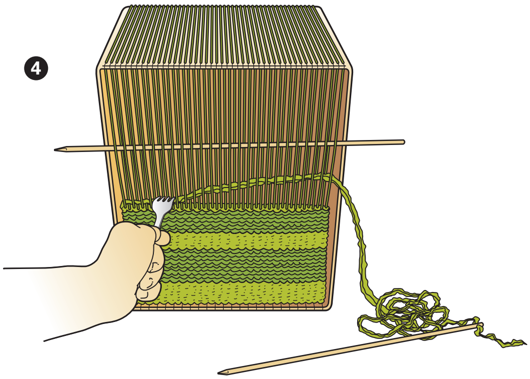
To weave the finished piece:

Step 1—Remove the scrap yarn from the shuttle (the weaving needle or your improvised dowel-rod shuttle). Thread the shuttle with the yarn you are using for the finished piece.

Step 2—Use the knitting needle or dowel exactly as you did before to pick up alternating warp threads.

Step 3—Draw the weft thread through the open shed. Arc or curve the weft thread as you draw it across, to put a little slack in it. If you draw it across too straight, it will pull on the warp threads when the weft or filling is beaten into place. This will cause the edges of the woven piece to draw in and may break the warp threads on the edges.

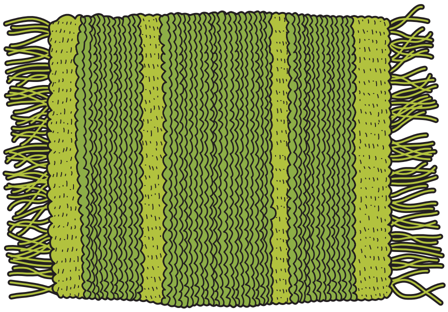
Step 4—Use the tines of a fork to "beat" (gently press) the weft threads into place, evenly across the loom. Take care to keep the edges of the weaving straight and parallel. If the edges draw in, it means you are pulling the weft threads too taut and straight across. Arc them as described in the previous step.



Step 5—Continue drawing the weft threads back and forth, alternating them with the warp threads and pressing them into place, until your weaving reaches the size you want for a place mat, wall hanging, or other project. Tie off the weft thread.

Step 6—To remove the weaving from the loom, cut the warp yarns across the middle of the bottom of the cardboard box. Remove two or three cut warp ends at a time from the loom, and tie each group together with an overhand knot. Repeat until all ends of the warp yarns are tied. (Remove the scrap header before knotting the warp ends at that edge of the finished piece.)

Step 7—To make a fringe, trim the warp ends no shorter than 2 inches. If they are any shorter, the weaving might unravel.



Try this: Draw on a piece of paper a design the size of your loom. Or, use a computer drawing program to make a design. Print the design on paper to match the size of your loom. Slip the drawn or printed design under the warp threads. Follow the pattern of the design as closely as you can to weave a picture.

The Art of Fabrics

From earliest times, people have used colors and various stenciling and printing methods to make themselves look better in the eyes of their gods and their mates, to frighten their enemies, or to make their homes more pleasant places to live.

For fabric colors, people have used bright berries, colored flowers, vegetables, insects, shellfish, tree bark, and natural earths. These natural colors are not very strong and usually fade over time or in bright sunlight. One of the great searches throughout history has been for colors and dyes that would keep their richness. In ancient Rome, a purple dye from a shellfish was so rare and highly prized that only the nobles could wear the color. People still use the expression "born to the purple" to describe a noble or an aristocrat.

It took people more than 2,000 years from the time of the Roman Empire to come up with a purple color that could be made cheaply. It was discovered by an Englishman still in his teens. In 1856 young William Henry Perkin invented the first chemical dye—a purplish color called mauveine.

The modern *aniline dye* industry sprang from this discovery. Modern textile technology uses 4,000 to 6,000 different dyes, practically all of which are chemically produced.

Industrial dyeing operation

How Dyeing Is Done

The typical method of coloring yarn or fabric is to dissolve the color in hot or boiling liquid and put the yarn or fabric in the solution. In some cases, other chemicals are added to speed up the process or to make the colors more uniform or permanent.

A fabric woven from dyed yarns can be more colorfast. By working with varied colored yarns, the weaver can create interesting designs such as plaids, stripes, and checks.

If masses of fibers such as wool or cotton are placed in the dye bath, it is called *stock dyeing.* If the fiber is spun into yarn before it is dyed, it is called *yarn dyeing.* If the fabric is woven and then dipped as whole cloth into the dye, it is known as *piece dyeing.*

Each method has its virtues. Piece dyeing is good for coloring large pieces of fabric in one color, but the item may fade in time if the dye has not penetrated to the innermost fibers. Jet dyeing under pressure is used today to get better penetration of dyes.

Using stock-dyed yarn gives the most colorfastness and uniformity of color. A textile maker can create interesting effects in the final fabric by mixing colored fibers before they are spun into yarns.

Another method of dyeing used in coloring manufactured fibers is to dissolve the color in the liquid from which the filaments are made. This puts the color "inside"—it is completely a part of the final fiber. This is called *solution dyeing* or dope dyeing.

Another method of dyeing, called c*ross-dyeing,* takes advantage of the fact that different fibers—say, wool and rayon—take the color in varying degrees, one slower or faster than the other. You can use cross-dyeing to get two or more tones from one dye.

Do Your Own Dyeing

With an old white shirt, pillowcases, or light-colored pair of slacks, you can try experimenting with dyes. At a supermarket or other store that sells fabric-care products, get a package or two of different-colored dyes—one a light color, one a dark. Follow the instructions on the box. Experiment with small pieces of similar material. Try to get a two-color effect by dyeing with the light color first, then dyeing the fabric again with the darker shade. Try tie-dyeing: Tie small knots in the fabric (or use rubberbands), dip in the dye, let it dry, and then untie the knots for a sunburst effect. Repeat with the other color. Remember, be sure to get your parent's permission and help before you begin.

Natural Dyes

You can use nonpoisonous berries, stems, bark, and flowers to make dyes that will color fabric or yarn. Use ripe berries, flowers at full bloom, freshly picked leaves, bark collected in spring or early summer, or roots collected in early fall. Also, before you begin, get your parent's permission and help.

Making Natural Dye

Step 1—Chop or break plants into small pieces and cover with water in a large pot. Soak overnight.

Step 2—Boil for an hour or more, until the color is much deeper than the color you want.

Step 3—Strain, to remove all pieces of plants.

Preparing the Material to Be Dyed

Be sure to wear household rubber gloves.

Step 1—Wash fabric in soap and water and rinse well.

Step 2—Add 1 ounce of alum (found in the spice section of most grocers) to a gallon of water. Also add ¼ ounce of washing soda (check the laundry detergent aisle) if fabric is made of a vegetable fiber—cotton, linen, or rayon. If fabric is made of an animal fiber—silk or wool—add ¼ ounce cream of tartar.

Step 3—Put fabric in this solution and boil for an hour. Rinse and dry.

Dyeing the Material

It's a good idea to wear household rubber gloves during the dyeing process, too.

Step 1—Use a kettle large enough to hold the dye and the fabric to be dyed. (An enamel kettle works well.) Add enough water so that the dye will cover the cloth.

Step 2—Bring the liquid to a boil and add the cloth. Stir with a wooden spoon or stick.

Step 3—Lift the cloth on the spoon so that you can see light through it. The color you see will be close to the color your fabric will be when it dries. You may have to boil the fabric in the dye from a half hour to an hour to get it the shade you want.

Step 4—*Set* the dye so it will not wash out: Add ½ cup of vinegar or 1 tablespoon of salt to the liquid in the kettle. Boil for 15 minutes.

Step 5—Remove the cloth from the dye and rinse it in cool water. Hang it in the shade to dry.

These Plants Make These Colors

Onion skins	Red or yellow	Sunflower seeds	Blue
Beets	Red-violet	Hickory bark	Brown
Dandelion roots	Magenta	Walnut hulls	Brown
Rhubarb leaves	Light green	Sumac leaves	Yellow-brown
Spinach leaves	Green	Goldenrod stalk and flowers	Yellow
Blackberries	Blue		

Printing Textiles

Many fabrics are printed rather than dyed. The process is basically the same, except that instead of color being applied to the whole area of cloth, it is applied to specific areas. The same dyes are used in both processes, but dye baths are liquid, whereas printing uses a thick paste of the coloring material.

Most fabric-printing today is done on high-speed presses much like those used in printing newspapers. A roller with a design etched into it is covered with ink and rolled across the fabric. When the roller touches the fabric, the inked portion leaves an impression on the cloth.

Another important printing method is called screening or the *silk-screen process*. A fine mesh or screen of nylon is stretched over a flat wooden frame. This screen is painted over in all areas except where the pattern is to be. The screen is laid over the fabric to be printed, and dye paste is placed in the frame. As the paste is squeegeed back and forth, it seeps through the exposed open mesh and colors the cloth underneath. Visit a local T-shirt printing shop to see silk-screening on a small scale. For large production, this process is done with elaborate, high-speed machinery.

In another process, called heat transfer printing, the design is printed on paper and then ironed onto the fabric. When the paper is peeled off, it leaves the design on the fabric. You can buy heat-transfer paper at craft shops and fabric stores.

Digital printing methods are also in use today. Digital printing produces prints with great clarity and vivid colors.

Print Your Own Fabric

You can print a fabric in much the same way as the first printed fabrics were made—by carving a design in a wood block, inking it with a roller, and pressing the block on a piece of cloth. Art supply stores or paint stores will have the ink and other items you need. Try printing your patrol design on a big handkerchief for each member of the patrol.

Finishing

Virtually all fabrics are called *gray goods* as they come from the loom or knitting machine. This term (also spelled *greige*, pronounced "gray") does not refer to the color of the cloth. It just means that the fabric has not been given any finishing treatments. To make certain that the fabric will be suitable for its final intended use, gray goods undergo many finishing processes, some of which occur before dyeing. Scouring, bleaching, and desizing are often necessary before the fabric can be dyed. Other finishing treatments help fabrics resist fading, flames, mildew, moths, static, stains, and water.

Here are some things that happen to fabrics after they leave the loom or knitting machine. For descriptions of these treatments and finishes, see the glossary.

- Antistatic finishes
- Bleaching
- Calendaring
- Desizing
- Flame-retardant finishes
- Mercerizing
- Mothproofing
- Napping
- Permanent press
- Sanforizing
- Scouring
- Shearing
- Singeing
- Sizing
- Soil-resistant finishes
- Water-resistant finishes

Waterproofing

Fabrics may be made water repellent in many different ways. Some water-repellent finishes will wash out; others are more permanent. Some water-repellent finishes make the fabric resistant to oil stains also.

With your parent's or counselor's assistance, here are some treatments you can use to make a piece of fabric water repellent. Be sure to work carefully and wear household rubber gloves.

1. Dissolve 1 ounce of gelatin in 1 pint of hot water. Dissolve ¼ pound of lye soap in 2 pints of hot water. Dissolve ¼ pound of alum in 1 pint of hot water. Mix the gelatin solution with the soap solution and place the fabric in this solution. Agitate the fabric in this solution for 5 minutes. Add the alum solution, mix well, and let it set for 5 minutes. Spread the fabric and let it dry. **Note:** Look for lye soap at your local natural products grocer. Alum can be found in the spice aisle at most supermarkets. The three solutions may be mixed and the mixture brushed on the fabric, if desired.

2. If your fabric is a loosely woven material, a paraffin solution will give complete waterproofing. Grate ½ pound of paraffin wax (found at most craft stores) and dissolve it in 2 quarts of turpentine. The wax will dissolve better if you warm the mixture in the sun; ***do not heat it on a fire.*** Spray or brush the fabric with the wax solution or submerge the fabric in the solution. Spread and hang the fabric and allow it to dry. *Do not use a dryer to dry the fabric.* Most of the turpentine will evaporate as the fabric dries.

The Textile Detective

One day you're doing laundry, and you have a pile of shirts that are missing their care labels. You don't know what the shirts are made of and without knowing that, you can't be sure how to wash them—or even if they are safe to wash. What do you do?

With this basic course in being the Sherlock Holmes of the fabric world, you can find out. Knowing how to identify fibers used in clothes, rugs, curtains, etc., is valuable in deciding on proper washing, dry cleaning, pressing, and storage. When you know the characteristics of the various fibers, you can buy clothes and household items more intelligently, too. You'll be sure to get the fiber that will do the best job.

To the naked eye, yarns pulled from pieces of cloth may look alike. But, like people, each yarn has its own personality and physical character. Here are some simple methods used to identify fibers.

Microscope Identification

If you have a microscope or can use one at school, you can magnify fibers to see their individual differences clearly. Start with a fabric you can identify from the label. Be sure it is 100 percent, not a 50/50 or 65/35 blend. If you examine a fiber from a mixed-fiber-blend fabric, you will not be sure which of the two fibers you are looking at.

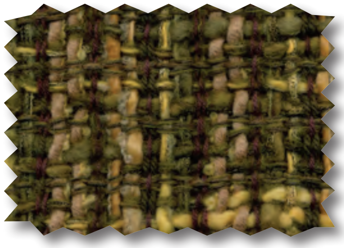
Unravel an all-cotton or pure-wool yarn, and place a few fibers under the microscope. On a 3-by-5 card or piece of paper, draw a picture of what you see and print the name of the fiber. Complete your collection by repeating this process with other natural fibers: silk, linen, jute, ramie. Compare these with the appearance of manufactured fibers such as nylon, acrylic, acetate, polyester, aramid, and olefin.

You will notice that the natural fibers have scales or a twisted or kinky construction. Cotton fiber, for instance, looks like a twisted ribbon under a microscope. The rough texture of natural fibers helps the fibers stay together when they are twisted into yarns. Manufactured fibers are smooth or have been given lengthwise grooves and specially treated to be crimped or twisted.

The Breaking Test

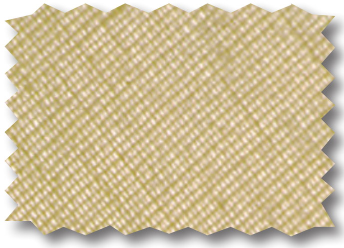
Fibers break in different ways. This fact can be helpful in identifying them. Start with threads you pull from the edge of an identifiable piece of fabric. Get a sample of yarn about a foot in length. Hold the ends in your fingers and pull the yarn apart. Observe the point of breakage, and compare to the descriptions that follow.

Cotton. Will show ends that are short, even, and fuzzy. There will be a curl to the ends.



Wool. Fuzzy surface, stretches easily, very elastic. The ends will be wavy and spiral.

Silk. Will stretch a lot and break with a snap. The ends will be fine and lustrous.



Linen. Strong, so you will need a long yarn. When pulled apart, the ends will be long, shiny, and pointed. Ends will not flare outward or curl.

Rayon. When dry, is quite strong. Breaks with treelike ends. If wet, yarn will break more easily.

Looking Good: You and Your Clothes

You will discover some practical, everyday reasons for learning about textiles. For one thing, knowing how fabrics are made can help you choose fabrics that are right for the job and show you how best to take care of them so they will last longer and keep looking good.

If you want to know how to take care of the clothes you buy, your Scout uniform, tents, and other equipment, look first at the hang tags that are attached to the items. Also check the labels sewn into clothes or other items made of fabric. Save the hang tags, read them, and give them to your parent to look over.

Here are some of the important terms you will find on fabric tags and labels, and their meanings.

Label	Meaning
Permanent Press	No ironing needed for the life of the garment.
Durable Press	Little or no ironing needed.
Waterproof or Rainproof	Water will not come through the fabric.
Rain Resistant	Will keep rain out for a reasonable time.
Water Repellent or Rain Repellent	Water sprinkled on the surface will bead and roll off. Surface finish may need to be restored by a dry cleaner.
Washable or Machine Washable	Wash, bleach, dry, and press by any customary method, including commercial laundry.
Delicate Cycle or Gentle Cycle	Set the dial of the washing machine to this reading or wash by hand.
Hand Washable or Wash by Hand	Launder only by hand in warm water.
Tumble Dry, Remove Promptly	Dry in a tumble dryer at the appropriate setting; in absence of a cool-down cycle remove at once when tumbling stops.
Block to Dry	Pull back into original shape while drying.
Commercial Clean or Professional Clean Only	Send to a commercial dry cleaner. Do not use self-service dry cleaning.
Sanforized	Garment has been preshrunk and is guaranteed to shrink no more than an additional 1 percent.
Preshrunk	Has been shrunk by the maker before sale but is not guaranteed not to shrink more.
Fire Retarding	Treated to resist flame but will burn if held in flame.
Mercerized	Fabric has been chemically treated to give it a high luster. Used on cotton fabrics.

Comparing Fabrics

The charts shown here list the fibers often used in making fabrics for clothes. Read the descriptions of the various fibers and the care summaries to help you decide whether a garment has the qualities or balance of qualities you want or need in a piece of clothing.

Natural Fibers

Fiber	Characteristics	Care
Cotton	Durable, soft, absorbent, strong, cool, comfortable. Easy to dye. Wrinkles easily unless special finishes are applied.	May be machine washed in hot water and dried. Finishes add to ease of care.
Linen	Absorbent, crisp, cool, durable. Wrinkles easily unless given special finish.	Must be dampened well and ironed at high temperature.
Silk	Luxurious, dyes well, lightweight, strong; resists wrinkles. May water spot. Weakened by long exposure to heat and moisture unless specially treated.	Dry cleaning preferred; some silks are washable, preferably by hand.
Wool	Warm, very durable, springs back into shape. Will shrink with exposure to heat and moisture unless specially treated.	Dry cleaning preferred, unless labeled washable. Must be protected from moths unless specially treated.
Ramie	Linen-like appearance; often blended with polyester, cotton, linen, and acrylic.	Machine washable; sometimes requires no ironing.

Manufactured Fibers

Fiber	Characteristics	Care
Acetate and Triacetate Arnel® Chromspun®	Smooth, drapes well. Weak when wet; dries quickly. Builds up static electricity.	Dry cleaning preferred unless labeled washable. Press carefully at low-heat setting.
Rayon Avril® Courcel® Zantrel®	Cool, comfortable, drapes well. Wrinkles easily. Tends to shrink.	Dry cleaning preferred. Some rayons are washable.
Lyocell Galaxy® Tencel®	Similar to rayon in feel. Breathable, lightweight, comfortable, drapes well. Resists wrinkling and shrinking.	Generally machine or hand washable in cold water. Drip drying preferred to machine drying.
Acrylic Acrilan® Creslan® Orlon®	Wrinkle-resistant. Wool-like feel and warmth. Builds up static electricity. Rubbing may cause "pilling" (matting into little balls).	Generally machine or hand washable. Remove oil stains before washing.
Metallic Lurex®	Heavy, stable. May be damaged by abrasion.	Hand washable. Do not rub or iron.
Olefin Herculon®	Strong, flexible, absorbs very little water.	Avoid high temperatures.
Polyester Dacron® Fortel® Kodel®	Colorfast, strong, holds its shape. Resists wrinkles, abrasions, moths, mildew, and bleach.	Washable; dries quickly. Needs little ironing. Pretreat oily stains before washing.
Spandex Lycra® Cleerspan®	Good stretch; springs back into shape. Resists abrasion and body acids.	May be machine washed in warm water. Dry in dryer at lowest heat setting.
Nylon Antron® Celanese®	Very strong, durable, lightweight; dries quickly.	Can be machine washed. Low or no heat usually recommended.

Textiles and the Environment

Producing fibers and making textiles requires large amounts of natural resources. Some of the resources used (such as fossil fuels) are *nonrenewable;* that is, they cannot be replaced. Once they are used up, they are gone forever.

Some methods of manufacturing textiles can cause air and water pollution. Some of the chemicals used in making and cleaning textiles can be harmful to people and the environment, and manufacturers must take precautions to minimize or eliminate the negative effects.

Major Environmental Concerns

To protect yourself and the environment, it is important that you learn about the environmental impact of textile production and care. Here are brief descriptions of some major issues. Can you think of ways these problems might be solved now or in the future?

Water Use

It takes water to grow fiber crops like cotton. Water for irrigating fields comes from streams, rivers, and lakes, or is pumped out of the ground. In some countries and in some U.S. states, more water is used for irrigation than for any other purpose. In regions of low rainfall or in times of drought, using large amounts of water to irrigate crops can dry up lakes, rivers, and wells.

Textile processing operations, from the scouring of natural fibers to the dyeing and finishing of fabrics, also use a great deal of water. Textile mills have traditionally been located near abundant sources of water.

As the world's population grows, the demand for water steadily increases. It is important that water resources be well-managed and conserved to prevent water waste and shortages.

Water Pollution

Chemical fertilizers and pesticides that are applied to fields of fiber crops may end up polluting rivers, lakes, and wells. Pollution also may come from textile mills. Most of the water used in a textile mill is released back into the environment. Untreated water often contains impurities such as waxes, greases, pesticides, dyes, detergents, and salts.

One vital pollution-control method is to treat the mill water to make it clean enough to go back into the environment. It is also important to use cleaner ways of growing crops and making textiles.

Many cotton producers, for example, no longer use synthetic pesticides on the soil or on plants to kill insects or prevent diseases. They remove weeds by hoeing their fields, and they use beneficial insects to help control insect pests.

Cotton textiles also may be made from naturally colored cotton fibers that need no dyeing. Cottons that naturally grow in colors have always existed in nature. Native peoples have long used them for hand spinning and weaving. Only recently, however, have plant breeders discovered how to combine the natural colors of wild cottons with the long, strong fibers of commercially grown white cottons. These colored cottons come from the field in rich shades of reddish brown, bronze, green, oatmeal, khaki, and similar natural colors.

By using yarns spun from the colored fibers, textile makers can avoid the high costs of dyeing. They save money by not buying dyestuffs, and they also save energy, water, and the expense of safely disposing of toxic dye wastes.

Organic cotton is grown without the use of pesticides, defoliants, or other chemicals. Allergy sufferers and other people who are sensitive to the chemicals used in many traditional textiles may prefer bed and bath linens made from organically produced cotton.

Human Health and Safety

Several substances that are used in making textiles can be dangerous to people. These include some preservatives, pesticides, resins, the heavy metals found in certain synthetic fibers and dyes, and dyes that are known to cause allergic reactions and have other harmful effects.

Resource Consumption and Air Pollution

Textile mills must use energy to make heat for such processes as dyeing, curing, heat setting, and drying. To generate the steam used in these processes, most mills burn coal, oil, or natural gas, or they use electricity produced from these fossil fuels. Burning fossil fuels for energy can release pollutant gases into the air.

Fuels are also consumed to move textiles around. In today's global economy, the raw fibers may have traveled around the world before being put to their intended use as a finished textile product. From an environmental perspective, it is better to use raw materials—whether fiber, yarn, or fabric—that are produced close to home.

Fossil fuels also provide the raw material for making synthetic fibers like nylon and polyester. Garments made from these synthetics are not *biodegradable*. That is, they cannot easily be broken down or naturally decomposed by the action of bacteria, sun, and rain. Clothing made from synthetics often will outlast its usefulness.

One partial solution to conserve resources might be to recycle petroleum-based materials into new products. The bottles are melted down into a resin and spun into fiber. It takes about eight two-liter containers to produce one sweatshirt. Plastic soda bottles, for example, are being recycled to make synthetic fiber.

Earth-Friendly Fabrics

It is important to realize that many textile products can be used to protect the environment. Fabrics known as "geotextiles" hold soil in place and help prevent erosion. Fabrics are used as filters to clean up air and water. Manufactured fibers can act as absorbents to remove spilled oil from water and wetlands. Many textile makers are working to develop environmentally sustainable textiles—that is, textiles that are economical in their use of energy and natural resources; that are clean to make and to care for, producing few waste products; and that are biodegradable, recyclable, or reusable.

Construction sites use geotextiles to help control erosion and drainage.

You can help protect the environment, and also influence the way things are done in the textile industry, by making responsible choices in the clothes, fabrics, and other textile products you buy.

A good way to evaluate or rate textiles according to their environmental benefits and drawbacks is to make a chart that lists the advantages and disadvantages of each major group. The chart shown here is partly filled in, to get you started. What other advantages or disadvantages can you think of for each textile group?

Responsible Choices

Textiles	**Advantages**	**Disadvantages**
Natural Plant Fibers • Cotton • Linen • Jute • Ramie	• Renewable plant resource (can be replaced by growing again) • Biodegradable • Recyclable • • •	• Chemical fertilizers and pesticides often applied to fields • Often require irrigation • • • •
Natural Animal Fibers • Wool • Mohair • Silk	• Renewable animal product • Biodegradable • Wool can be reused • •	• May require dry cleaning using chemical solvents • • •
Cellulosic Manufactured Fibers • Rayon • Acetate • Lyocell	• Made from wood pulp (renewable plant resource) • Can be made from plant waste products such as sawdust or cotton linters • Biodegradable • •	• Treated with solvents and chemicals during production • May require dry cleaning with chemical solvents • • • •
Synthetic Manufactured Fibers • Nylon • Polyester • Acrylic • Spandex • Aramids • Olefin	• Strong, durable • Versatile • Easy to care for (machine washable) • • • • •	• Made from nonrenewable petrochemicals • May outlast usefulness • Not biodegradable (break down very slowly, like plastic) • • • •

Textiles, Tomorrow, and You

In the textile industry are many interesting and unusual careers. If you can visit a textile mill or manufacturer, talk to people who work there and ask about their responsibilities. Here are a few examples of some of the fields you might discover.

Engineer

The average textile operation has mechanical, electrical, chemical, and industrial engineers as well as textile engineers who handle the many complicated processes and operations in developing and making thousands of textile products. If you like to operate or repair machines, you will find highly unusual and complicated machines in a textile plant.

Scientist

The textile industry employs top-notch scientists whose research leads to new fibers and to new ways of using fabrics and textiles. Textile companies need people trained in chemistry, physics, and biology.

Artist or Writer

All printed fabrics, upholstery, carpet designs, towels, sheets, and ties are designed originally by artists. Most fabric designers work for companies that make fibers, fabrics, or clothing. They must know enough about making textiles to know whether their creative ideas can be used in actual products.

Thinking about a career in textiles? Two subjects to study are computers and foreign languages. Computers now play an essential role in textile design and manufacturing, and they are constantly getting more sophisticated. You also will need a knowledge of foreign languages because today's textile industry is global.

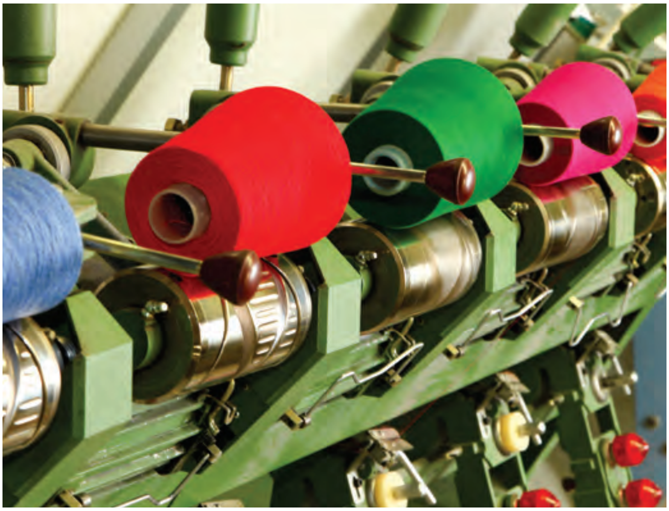
If you are good in English, a textile company might hire you to work in its advertising or public relations departments. You see fabric advertisements in magazines and newspapers and look at television commercials for items made of fabrics. This work is done by artists and writers who work either for the textile companies or for their advertising agencies.

Sales Representative

Selling calls for people who like people, who welcome challenges, who are enthusiastic, and who know the product they sell inside and out. If you think you have these qualities, you could think about a career in textile sales, sales management, or marketing. Many textile companies have training courses for sales representatives.

Other Professions

Many careers in textiles require college training. If you are in high school, talk to your guidance counselor or a teacher about your ideas for your future. In addition, you can write to the schools for catalogs and pamphlets describing their programs. See the resources chapter for a list of schools and colleges that offer special programs for careers in textiles.



Textile Graduates Are in Demand

The U.S. textile industry is the second leading contributor to the gross domestic product, second only to the auto industry. The textile industry consists of more than 30,000 fiber, textile, and apparel companies. As the industry moves into the 21st century, college graduates must meet the challenges and complexities of a high-tech industry.

What Career Opportunities Are Available in Textiles?

Textile Engineering
Chemical process engineer
Industrial engineer
Information systems engineer
Machine design engineer
Process engineer
Product design engineer
Quality engineer
Research and development engineer
Technical management
Technical sales

Textile and Apparel Management
Apparel design
Computer integrated manufacturing
Distribution and sales
Human resources
Manufacturing management
Marketing and merchandising
Product development production planning
Quality control
Technical services

Textile Chemistry
Chemical manufacturing
Color science
Dyeing and finishing preparation
Environmental protection
Polymer synthesis and production
Technical sales and service

Textile Technology
Color forecasting
Freelance design
Graphic design
Manufacturing management
Process control
Product development
Quality management
Styling
Technical sales

Textile graduates typically go to work for a textile company in one of the fields listed above. Some continue their education in graduate programs. About 25 percent go to work outside the textile industry in one of the fields listed below.

Other Career Options
Armed forces
Banking
Computer programming
Consulting
Education
Finance
Government
Law
Medical
Pharmaceuticals
Software development

—From Kent Hester, director of Student and Career Services, College of Textiles, North Carolina State University

Glossary

acetate. A manufactured fiber made from chemically modified cellulose, refined from cotton linters or wood pulp, and squeezed through a spinneret and then hardened.

acrylic. A synthetic manufactured fiber that feels like wool.

aniline. A chemical from which many dyes are made.

antistatic. A finish that reduces static electricity and the tendency of a fabric to cling, especially fabrics made from manufactured fibers.

aramid. A kind of synthetic fiber, very strong and resistant to high temperatures. Kevlar and Nomex are examples.

asbestos. A fibrous mineral used for making fireproof articles. Asbestos is very dangerous to human health if breathed into the lungs.

beating. Pushing the loose filling yarns into place in a woven fabric by striking them with the reed.

bleaching. Chemical treatment to remove impurities and whiten the fabric; can be done either in preparation for dyeing and finishing or to get bright whites in the finished fabric.

blend. A yarn or a fabric that is made up of more than one fiber. In blended yarns, two or more different types of staple fibers are twisted or spun together.

bobbin. A spool upon which yarn is wound.

breaking. Cutting flax stalks into short pieces to get at the fibers.

calendering. A process for finishing fabrics by passing them through heavy rollers under pressure and usually heat to add special effects.

carbon fibers. Strong, stiff, thin fibers of nearly pure carbon.

carding. Partially straightening and cleaning fibers before spinning. Carded yarn is generally coarser and more uneven than combed yarn.

cellulose. A natural substance based on glucose (a sugar) found in the cell walls of plants. Cellulose is an important part of plant fibers like cotton and flax, and is the major raw material used for the manufactured fibers of rayon, acetate, and lyocell.

cellulosic. Made from cellulose. Compare to *synthetic.*

colorfastness. A dyed fabric's ability to resist fading from washing, exposure to sunlight, and other environmental conditions.

combing. An additional step beyond carding that gets the fibers highly parallel and removes the shorter, undesirable fibers. Combed yarns are finer, cleaner, and more even than those that are not combed.

count. A number indicating the fineness or coarseness of yarn. Counts in denim, for example, range from 5 to 12, whereas counts in shirting can range from 28 to 50 and even higher.

crease resistant. A finish that reduces a fabric's tendency to crease and wrinkle.

cross-dyeing. A method of coloring fabric made from yarns of different fibers, by dyeing the fabric with different dyes for each type of yarn.

desizing. Breaking down sizes (stiffeners, starches, or glazes) that were applied to the yarns before fabric making.

distaff. A staff for holding fibers for spinning by hand.

dobby loom. A loom equipped with a special attachment (the dobby) that controls the harness, allowing the weaving of small, geometric or floral patterns.

double knit. A weft-knit fabric formed by using two sets of needles knitting face loops and back loops into the fabric.

drafting. Drawing or pulling out fibers in spinning, either by hand or by machine.

dry cleaning. Cleaning fabrics with chemicals, not water.

durable press. A finishing treatment applied to a fabric so that the fabric stays smooth, resists wrinkling, and keeps its creases or pleats during laundering.

elasticity. The ability of a fiber or fabric to return to its original length, shape, or size immediately after being stretched out of shape; its springiness.

fabric. A cloth made by weaving, knitting, or bonding fibers.

felt. A nonwoven fabric of pressed, matted fibers.

fiber. A fine, slender, threadlike strand, either natural or manufactured, that is twisted into yarns and then used to make a fabric.

filament. A long, continuous fiber; a manufactured fiber of indefinite length (continuous), extruded from the spinneret during the fiber production process.

filling yarns. In a woven fabric, the yarns that run crosswise to the warp or lengthwise yarns. Also called *pick* or *weft*.

finish. Any process a fabric goes through after it is woven or knitted to make it wear longer, be easier to care for, or be more attractive.

flame resistant. A finish that prevents fabric from spreading a flame. A flame-resistant fabric stops burning when removed from the flame.

flame retardant. A chemical applied to a fabric or added to the fiber at the time of production, to give protection against flame flareup.

flax. A slender, annual plant grown for its fiber and seeds. The fiber of the flax plant is made into linen yarn.

full-fashioned. Knitted to conform to the shape of the body.

gin. A machine for separating the fibers of cotton from the seeds.

gray goods. Unfinished fabric; fabric as it comes from the loom or knitting machine, before it has gone through any finishing processes.

greige goods. See *gray goods.*

hackling. Combing, as flax or hemp.

harness. On a loom, the frame containing heddles through which the warp is drawn and which, in combination with another frame or frames, forms the shed and determines the woven pattern.

heddle. On a loom, the main part of the harness that guides the warp yarns.

hemp. A tall, coarse plant native to Asia. A tough fiber, valuable for making rope, comes from its inner bark.

herringbone. A broken twill weave with rows of slanting lines that form zig-zag V's. Also called fishbone.

jacquard. A fabric with a complicated pattern woven or knit into it as part of its structure.

jute. A strong, coarse fiber, chiefly from India, used for making burlap, gunny sacks, and carpet backs.

knitting. Making a fabric by interlocking loops of one or more yarns, either by hand with knitting needles or by machine.

line. The longer, better flax or hemp fibers. Compare to *tow.*

linen. Fibers taken from inside the woody stem of the flax plant.

linters. The short fibers remaining on cottonseeds after the longer fibers have been removed by the cotton gin.

loom. A hand-operated or power-driven device for weaving fabrics.

lyocell. A manufactured fiber made from cellulose; similar to rayon but stronger.

manufactured fibers. Fibers made through chemical processes, such as polyester, nylon, and spandex.

mercerization. A chemical finishing process with caustic soda that removes impurities and loose surface strands from a yarn or fabric and gives it a shiny look. Mercerizing makes cotton and linen fabrics lustrous, stronger, more durable, and easier to dye.

mildew resistant. A finish that slows or prevents the growth of mildew and mold.

moth resistant. A finish that discourages insects from attacking wool fibers.

napping. A finishing process to produce a soft, fleecy surface on smooth, hard fabrics, using brushes or wire teeth to rub the fabric surface to create the desired appearance.

natural fibers. Fibers found in nature, such as cotton, wool, linen, and silk.

nonrenewable. Not capable of being replaced or replenished.

nonwoven. Made of fibers matted, tangled, fused, glued, or melted together.

nylon. The first completely synthetic fiber, known for its strength and resilience.

olefin. A synthetic manufactured fiber often used for indoor-outdoor carpets and lawn furniture.

permanent press. A fabric treatment that sets the shape and aids in wrinkle resistance for a smooth appearance after laundering.

petrochemicals. Chemicals from crude oil and natural gas.

pick. Filling yarns; weft. Also, one passage of the filling insertion mechanism in a loom.

piece dyeing. Coloring a fabric by dipping it as a whole cloth into a dye bath.

ply. Two or more yarns twisted together. Three-ply yarn, for example, consists of three strands of yarn twisted together for added strength.

polyester. The most widely used synthetic manufactured fiber; it is second only to cotton in worldwide use.

preshrunk. Put through a shrinking process before marketing to keep later shrinking minimal.

ramie. A strong natural fiber taken from the stalk of an Asian shrub of the nettle family.

raschel knit. A warp-knitted fabric that resembles hand-crocheted fabrics, lace, and netting.

rayon. A manufactured fiber made of cellulose from wood pulp, cotton linters, or other plant matter.

reed. In a loom, the parallel, comblike wires that force the filling yarns tightly up against the rows already woven.

retting. Soaking flax or hemp in water or exposing to moisture to make it easier to remove the fiber from the woody tissue.

roving. Forming slivers of fibers into slightly twisted strands; a step in spinning.

Sanforizing. A trademarked finishing process to preshrink fabrics so that they will shrink very little in laundering.

scouring. Washing cotton or wool to remove dirt, grease, and other impurities that might cause uneven dyeing.

scutching. Dressing or preparing flax by beating.

sericulture. Raising silkworms to make silk.

shearing. Clipping the wool from sheep. Also, a finishing process used in carpet making to obtain the desired pile height and loft. The process consists of passing the unfinished carpet over precisely set knife edges that cut yarns to required lengths.

shed. On a loom, the opening created between raised and lowered warp yarns through which the shuttle or other filling insertion mechanism carries the crosswise filling yarns.

shedding. Raising warp yarns to make a shed.

shrink resistant. A treatment that helps fabric retain its original size and shape after laundering. Labels should give the percentage of shrinkage to be expected when the item is washed, such as "Guaranteed not to shrink more than 1%."

shuttle. A device in a loom for passing or shooting the weft or filling yarn through the shed from one side to the other; traditionally a boat-shaped piece of wood with a bobbin on which the filling yarn is wound.

silk-screening. A printing method in which a mesh cloth (screen) is stretched over a heavy wooden frame, and the design that is printed or stenciled on the screen is printed by using a squeegee to force dye paste through the openings in the screen in areas not blocked out.

singeing. Burning or scorching off the fuzz or nap on a fabric to get a smooth surface.

sizing. A solution of starch or resin applied to warp yarns to stiffen them for weaving, or to a fabric to temporarily increase weight, luster, and body.

slashing. Applying a protective film, usually starch or a synthetic, to warp yarns to make them stiffer and easier to handle on a loom. See *sizing.*

sliver. A loose rope of untwisted or loosely twisted fibers produced in carding and combing.

soil release. A finish used to make soils and stains easier to remove from fabrics.

soil resistant. Finishes applied to clothing, upholstery, draperies, floor coverings, and bedding to help keep stains from penetrating.

solution dyeing. A way of dyeing manufactured fibers in which colored pigments are mixed into the syrupy solution before the solution is extruded through a spinneret to form fibers. Fibers and yarns dyed in this way are highly colorfast.

spandex. A highly elastic, synthetic manufactured fiber; it can be repeatedly stretched without breaking and will recover to its original length.

spin. To make yarn by drawing out, twisting, and winding fibers.

spindle. A rod, usually made of wood, used in hand-spinning to twist the fibers drawn from the mass on the distaff, and upon which the yarn is wound as it is spun.

spinneret. The body part that a spider or caterpillar uses to spin silk for its web or cocoon; or, a metal plate or nozzle with tiny holes through which a chemical solution is extruded to make continuous filaments.

spinning. Twisting staple (short) lengths of fiber into continuous yarn.

stain resistant. A finish that makes fibers less absorbent so it is easier to wash off stains.

staple fibers. Short fibers, typically ranging from ½ inch up to 18 inches long. Wool, cotton, and flax exist only as staple fibers. Manufactured fibers can be cut to a staple length from the continuous filament.

stock dyeing. Dyeing staple fiber before it is spun into yarn; a common method for woolen fabrics.

synthetic. In textiles, a manufactured fiber made from petrochemicals. Compare to *cellulosic.*

textile. Any fiber, filament, yarn, or fabric or anything made of fiber.

tow. The shorter flax fibers separated from the longer fibers (line) in hackling. *Tow* is also the name given to a sliver of synthetic (especially continuous filament) fibers.

tricot. A warp-knit fabric with fine vertical ribs on the face and crosswise ribs on the back.

twill weave. A basic weave in which the warp and filling yarns are interlaced in a way that creates a diagonal effect.

warp. In a woven fabric, the yarns that run lengthwise and are interlaced with the weft (filling) yarns.

warp knit. A knitted fabric produced by interlocking loops in a lengthwise direction; common examples are tricot knits and raschel knits.

waterproof. Fabrics whose pores have been closed, and therefore will not allow water or air to pass through them.

water repellent. Fabrics that have been treated with a finish that causes them to shed water. The finish does not close the pores of the fabric as waterproofing does, so the fabrics are still permeable to air.

water resistant. See *water repellent.*

weaving. Interlacing yarns to make a fabric; or, interlacing other materials, like strips of wood or leaves, to make an item like a basket or a mat.

weft. In woven fabric, the filling yarns that run crosswise to the warp yarns.

weft knit. A knitted fabric formed by interlocking loops in the widthwise direction; common examples are double knits and rib knits.

whorl. A flywheel or weight for a spindle.

woolen. A fabric of carded wool in which the fibers vary in length; looser, bulkier, and less regular than worsted.

worsted. A tightly woven fabric made by using only long-staple, combed wool or wool-blend yarns. The fabric has a hard, smooth surface and no nap.

yarn. A continuous strand of textile fibers created when a mass of individual fibers is twisted together to create fabrics.

yarn dyeing. Dyeing yarns before they are made into fabrics.

35958(19)_Textile_MBP_Pages.indd 75 2/22/19 1:32 PM

Textile Resources

Scouting Literature

American Business, Animal Science, Art, Basketry, Chemistry, Energy, Environmental Science, Graphic Arts, Indian Lore, Insect Study, and *Plant Science* merit badge pamphlets

With your parent's permission, visit the Boy Scouts of America's official retail website, www.scoutshop.org, for a complete listing of all merit badge pamphlets and other helpful Scouting materials and supplies.

Books

Alvarez, Nilda Callanaupa. *Textile Traditions of Chinchero: A Living Heritage.* Thrums LLC, 2012.

Barber, Elizabeth Wayland. *The Mummies of Ürümchi.* W.W. Norton, 2000.

Brown, Rachel. *The Weaving, Spinning, and Dyeing Book.* Knopf, 1983.

Burningham, Veronica. *Weaving Without a Loom.* Search Press, 1998.

Crolius, Kendall, and Anne Montgomery. *Knitting With Dog Hair.* St. Martin's, 1997.

Dean, Jenny, and Karen Diadick Casselman. *Wild Color.* Potter Craft, 2010.

Delaney, Connie. *Spindle Spinning: From Novice to Expert.* Kokovoko Press, 1998.

Garfield, Simon. *Mauve: How One Man Invented a Color That Changed the World.* W.W. Norton, 2001.

Gordon, Beverly. *Textiles: The Whole Story: Uses, Meanings, Significance.* Thames & Hudson, 2011.

Joseph, Marjory L., et al. *Joseph's Introductory Textile Science.* 6th ed. Holt, Rinehart and Winston, 1992.

Kadolph, Sara J. *Textiles: Basics.* Prentice Hall, 2012.

Keeler, Patricia A., and Francis X. McCall Jr. *Unraveling Fibers.* Atheneum, 1995.

Macaulay, David. *Mill.* Houghton Mifflin, 1989.

McGrayne, Sharon Bertsch. *Blue Genes and Polyester Plants: 365 More Surprising Scientific Facts, Breakthroughs, and Discoveries.* John Wiley and Sons, 1997.

Schoeser, Mary. *Textiles: The Art of Mankind.* Thames & Hudson, 2012

DVDs

Unicorn Projects Inc. *Mill Times.* PBS Home Video.

Magazines

Ecotextile News

Website: http://www.ecotextile.com

Textile World

Website: http://www.textileworld.com

Organizations and Websites

All Fiber Arts

Website: http://www.allfiberarts.com

American Fiber Manufacturers Association

Telephone: 703-875-0432
Website: http://www.fibersource.com

American Sheep Industry Association

Telephone: 303-771-3500
Website: http://www.sheepusa.org

American Textile History Museum

491 Dutton St.
Lowell, MA 01854
Telephone: 978-441-0400
Website: http://www.athm.org

The Center for Traditional Textiles of Cusco

Website: http://www.incas.org/SPChinchero.htm

Fabrics.net

Website: http://www.fabrics.net

FiberWorld

Website: http://www.fiberworld.com

Mohair Council of America

Telephone: 325-655-3161
Website: http://www.mohairusa.com

National Cotton Council of America

P.O. Box 2995
Cordova, TN 38088-2995
Telephone: 901-274-9030
Website: http://www.cotton.org

Textile Resources on the World Wide Web

Website: http://libguides.uwstout.edu/content.php?pid=18267&sid=124796

Textile Colleges

The schools listed below offer a general college education with a specialization in textiles, leading to degrees in textile engineering, textile management, textile chemistry, textile design, and textile marketing.

Auburn University
Polymer and Fiber Engineering
Samuel Ginn College of Engineering
Auburn, AL 36849
Website: http://www.eng.auburn.edu/txen

Clemson University
School of Materials Science and Engineering
Clemson, SC 29634
Website: http://www.clemson.edu/majors/materials-science-and-engineering

Georgia Institute of Technology
School of Materials Science and Engineering
771 Ferst Drive
J. Erskine Love Building
Atlanta, GA 30332-0245
Website: http://www.mse.gatech.edu

Institute of Textile Technology
Box 8301
Raleigh, NC 27695-8301
Website: http://www.itt.edu

North Carolina State University
College of Textiles
Raleigh, NC 27695-8301
Website: http://www.tx.ncsu.edu

Philadelphia University
School of Design and Engineering
4201 Henry Ave.
Philadelphia, PA 19144
Website: http://www.philau.edu/designandengineering

Southern Polytechnic State University
Apparel Textile Technology
1100 S. Marietta Parkway
Marietta, GA 30060-2896
Website: http://spsu.edu/iet/iet_att

University of Massachusetts, Dartmouth
Materials and Textiles
285 Old Westport Road
North Dartmouth, MA 02747-2300
Website: http://www.umassd.edu/engineering/mtx

Research Centers

Clemson Apparel Research
500 Lebanon Road
Pendleton, SC 29670
Website: http://car.clemson.edu

Fiber and Biopolymer Research Institute (formerly International Textile Center)
Texas Tech University
1001 East Loop 289
Lubbock, TX 79403
Website: http://www.pssc.ttu.edu/fbri

Navy Clothing and Textile Research Facility
Building #86 DSN 256-4172
Kansas Street
Natick, MA 01760

Texas A&M AgriLife Research and Extension Center
Texas A&M University
7887 U.S. Highway 87 North
San Angelo, TX 76901
Website: http://sanangelo.tamu.edu

TRI/Princeton
601 Prospect Ave.
Princeton, NJ 08540
Website: http://www.triprinceton.org

Yocom-McColl Testing Laboratories Inc.
540 W. Elk Place
Denver, CO 80216-1823
Website: http://www.ymccoll.com

Acknowledgments

The Boy Scouts of America gratefully acknowledges the following textile educators and industry professionals who contributed generously to this edition of the *Textile* merit badge pamphlet:

- Kay Caddel, former national executive secretary/treasurer, Phi Psi Fraternity, a textile fraternity emphasizing scholastic achievement, professional ethics, and leadership
- College of Textiles, North Carolina State University; in particular, Wade Carter, extension specialist and In-Plant Program director (now retired), and Kent Hester, director, Student and Career Services (now retired)
- International Textile Center (now the Fiber and Biopolymer Research Institute), Texas Tech University, Lubbock, Texas; in particular, textile engineer James L. Simonton, communications coordinators Mike Stephens and Scott Irlbeck, and analytical chemist Bobby G. Wyatt
- Dr. Christopher J. Lupton, professor emeritus, Agricultural Research and Extension Center at San Angelo, The Texas A&M University System
- Ted Settle, Sportswear Graphics, Fort Worth, Texas, for assistance with photography
- Emerson Tucker, Plains Cotton Cooperative Association, Lubbock, Texas (now retired)
- Dave Williams, National Space Science Data Center, NASA Goddard Space Flight Center, Greenbelt, Maryland, for information about textiles on board the Mars Pathfinder
- Tommy Woolam, Woolam Gin, O'Donnell, Texas

The Boy Scouts of America is grateful to the men and women serving on the National Merit Badge Subcommittee for the improvements made in updating this pamphlet.

Portions of the 2003 edition were adapted from the 1972 edition written by John Hayward.

Photo and Illustration Credits

International Textile Center, Texas Tech University, Lubbock, Texas, courtesy—pages 28 *(machinery)*, 29 *(spinning, winding)*, 31 *(automated loom)*, 35, and 47

Northwestern University Library, Edward S. Curtis' "The North American Indian: The Photographic Images," 2001, courtesy—page 11

Shutterstock.com—cover (*spinning wheel*, ©Berents; *yarn,* ©ZHIDKOVA ANNA; *parachute,* ©Ensuper; *cotton plant,* ©Alter-ego); pages 3 (©Joy Tasa), 5 (©vladimir salman), 18 (©Stefano Garau), 54 (©tmcphotos), 57 (*cotton* ©Piotr Zajc; *wool,* ©BrankaVV; *silk,* ©Jaxja; *linen,* ©Andy Piatt; *rayon,* ©Monte Rego Images), 58 (©Kzenon), 64 (©Alter-ego), 65 (©vladimir salman), 68 (©David Crockett), and 70 (©photobank.ch)

Wikipedia.org, courtesy—pages 10, 16 *(flax field)*, and 19

All other photos and illustrations are the property of or are protected by the Boy Scouts of America.

Dan Bryant—page 23

Daniel Giles—page 62

John McDearmon—all illustrations on pages 7, 12, 16, 24, 34, 37, 43–45, and 56

Brian Payne—page 8

Randy Piland—page 23

The BSA thanks the American Textile History Museum in Lowell, Massachusetts, for its cooperation with the 2003 edition of the *Textile* merit badge pamphlet. The Museum is dedicated to collecting, preserving, and interpreting "objects and information about the design, production, and use of textiles to increase the enjoyment and understanding of textiles in America." The photos you see on pages 4, 14, 20, 26, 28 *(carding)*, 29 *(roving)*, 30, 31 *(hand loom)*, 32–34, 38, 49, 54, and 66 *(recycling series)* were taken at the Museum, with the cooperation of Lowell's Troop 6.

35958(19)_Textile_MBP_Pages.indd 80 2/22/19 1:32 PM