Learning Activity 4

Work in groups of two to four. Describe the sustainability of wool. Identify the positive and negative aspects of wool in terms of sustainability. Is wool a sustainable fiber? Explain your answer.

Many wool products require dry cleaning. Some dry-cleaning solvents have been identified as possible carcinogens and restrictions regarding workplace exposure exist.

Uses of Wool

Only a small amount of wool is used in the United States. In 2007 domestic consumption of wool comprised only a fraction of a percent of all fiber used in the United States. The most important use of wool is for adult apparel.

Wool suits perform well and look great. They fit well because they can be shaped through tailoring. The durable fabrics drape well. They are comfortable under a variety of conditions and retain their appearance during wear and care. Suits are usually dry-cleaned to retain their appearance and shape. Suit materials are also made of synthetic fiber/wool blends.

The Wool Bureau has adopted two symbols to assist in the promotion of wool. The Woolmark® is used on all 100 percent wool merchandise that meets their quality specifications; the Woolblend® mark is for blends with at least 60 percent wool. Both symbols are shown in Figure 10.

Even though the amount of wool used in interiors is low, wool constitutes the standard by which carpet appearance is judged. A major use of wool is in carpets and custom rugs, often special-order or one-of-a-kind rugs. Wool rugs can be machine-woven (Axminster or Wilton types), hand-woven, or hand-hooked. Most rugs are imported, although some are made in the United States. Wool carpets and rugs are more expensive than those made from other fibers because the rich color, texture, and appearance of wool are appreciated and valued. Wool carpets and rugs account for less than one-fifth of the floor-coverings market.

Both wool and wool-blend fabrics are used in upholstery because of their aesthetic characteristics, good appearance retention, durable nature, and natural flame resistance. For residential use, no additional flame-retardant treatment may be necessary; but for many commercial and contract uses, wool or wool-blend upholstery fabric may require a flame-retardant finish.

Handcrafted wall hangings and woven tapestries are often made of wool because textile artists like the way the fiber handles. Designers, artists, and consumers appreciate the way the finished item looks and wears.

Many school laboratories have fire-safety blankets made of wool. Stadium blankets and throws are often made of wool for warmth and an attractive appearance.

Wool is used in felts as foundation pads under heavy machinery to help decrease noise and vibration as well as for other uses. Tiny balls of wool that absorb up to 40 times their weight in oil are used to clean up oil spills. Wool mulch mats are used for landscape and horticultural weed control.
Table 3 Groupings of Specialty Wools

<table>
<thead>
<tr>
<th>Goat Family</th>
<th>Camel Family</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angora goat—mohair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cashmere goat—cashmere and pashmina</td>
<td>Camel hair</td>
<td></td>
</tr>
<tr>
<td>Llama</td>
<td>Angora rabbit—angora</td>
<td></td>
</tr>
<tr>
<td>Alpaca</td>
<td>Fur fibers</td>
<td></td>
</tr>
<tr>
<td>Vicuña</td>
<td>Musk ox—qiviut</td>
<td></td>
</tr>
<tr>
<td>Guanaco</td>
<td>Yak</td>
<td></td>
</tr>
</tbody>
</table>

Specialty Wools

Most specialty wools are obtained from the goat, rabbit, and camel families (Table 3). Specialty wools are available in smaller quantities than sheep's wool and are usually more expensive. Like all natural fibers, specialty wools vary in quality. Most specialty wool products require dry cleaning.

Specialty wool fibers are of two kinds: the coarse, long outer hair and the soft, fine undercoat. Coarse fibers are used for interlinings, upholstery, and some coatings; the fine fibers are used in luxury coatings, sweaters, shawls, suits, dresses, and interior textiles.

Mohair

Mohair is the hair fiber of the Angora goat. Major producers are South Africa, the United States, Turkey, and Lesotho. Texas is a major producer, but most U.S. mohair is exported. The goats (Figure 11) are usually sheared twice a year, in the early fall and early spring. Each adult goat yields about 5 pounds of fiber. The fiber length is 4 to 6 inches if sheared twice or 8 to 12 inches if sheared once a year. Approximately 12 percent of the crop is kid (baby goat) mohair, and the remaining 88 percent is adult mohair.

Mohair fibers are slightly coarse (average diameter of 25 microns for kid mohair and 40 microns for adult mohair) and have a circular cross section. Scales on the surface are scarcely visible, and the cortical cells may appear as lengthwise striations. There are some air spaces between the cells that give mohair its lightness and fluffiness. Few fibers have a medulla.

Mohair is a very resilient fiber because it has fewer scales than wool and no crimp. Mohair fibers are smoother and more lustrous than wool fibers (Figure 12). Mohair is very strong and has a good affinity for dyes. The washed fleece is a lustrous white. Mohair is less expensive than many other specialty wools. Mohair's chemical properties are very similar to those of wool. Mohair makes a better novelty loop yarn than wool or the other specialty hair fibers.

Mohair's good resiliency is used to advantage in hand-knitting yarns, pile fabrics, and sittings. Because it resists crushing and pilling, it is used in flat and pile upholstery fabrics and hand-produced floor coverings. Its natural flame resistance, insulation, and sound absorbency make it ideal for specialty drapery applications. Blankets of mohair blends retain heat well. Mohair is used to produce natural-looking wigs and hairpieces. Mohair is often blended with wool to add sheen and texture to apparel and interior textiles.

Figure 13 shows the quality symbol used on all mohair products that meet performance standards established by the Mohair Council of America.
Qiviut

Qiviut (qé-ve-ute), a rare and luxurious fiber, is the undervool of the domesticated musk ox (Figure 14). A large musk ox provides about 6 pounds of wool each year. The fiber can be used just as it comes from the animal, for it is protected from debris by the long guard hairs and has low lanolin content. Qiviut resembles cashmere in hand and texture but is much warmer. The fleece is not shorn but is shed naturally and is removed from the guard hairs as soon as it becomes visible. Producers in Alaska and Canada raise musk ox and harvest the fiber. Qiviut is expensive and used to produce handcrafted items by fiber artists, Inuit, and other Native American people.

Angora

Angora is the hair of the Angora rabbit produced in Europe, Chile, China, and the United States (Figure 15). It is harvested up to four times a year by plucking or shearing. Fiber yield and quality vary with the rabbit and its health and breed, and ranges from 8 to 30 oz. Of the four breeds of Angora rabbits, the two most common types are English and French. English Angoras produce a fine silky fiber; French Angoras produce a coarser fiber.

The white or naturally colored fiber is very fine (13 microns), fluffy, soft, slippery, and fairly long. Angora does not take dye well and usually has a lighter color than other fibers with which it is blended. It is often blended with wool to facilitate spinning because the slick fiber has poor cohesion. Angora is used in apparel such as sweaters and suitings and in knitting yarn.

If a label states “rabbit hair,” this means the fiber is from a common rabbit, not an Angora rabbit. Rabbit hair is often used to make felt for hats, but it is too short to make into yarn for woven or knit fabrics.

Camel Hair

Camel hair is obtained from the two-humped Bactrian camel. Major producers of camel hair include China, Mongolia, Iran, Afghanistan, Russia, New Zealand, Tibet, and Australia. Camel hair is an excellent insulator. The hair is collected as it is shed or sheared from the animals. A camel produces about 5 pounds of hair a year.

Because camel hair gives warmth without weight, the finer fibers are valued for apparel. They are often used in blends with sheep’s wool, which is dyed the tan color of camel hair. Camel hair is used in coats or jackets, scarves, and sweaters. Blankets of camel hair and wool are also available.

Cashmere

Cashmere is produced by the small cashmere goat (Capra hircus laniger) raised in China, Mongolia, Tibet, Afghanistan, and Iran. Cashmere production is a main source of income for the herders in these countries. The fibers vary in color from white to gray to brownish gray. The goat has an outercoat of long, coarse hair and an innercoat of down. The hair usually is combed by hand from the animal during the molting season. In dehairing, the coarse hair is separated from the fine fibers (13–18 microns). The downy fine fibers make up only a small part of the fleece, usually about one-half pound per goat. The fiber is solid, with no medulla and with fine scales. Cashmere is graded by color, tensile strength, and freedom from contamination with other fibers or plant residue. Cashmere is used for sweaters, coats, suits, jackets, loungewear, and blankets. Fabrics are warm, buttery in hand, and have beautiful draping.
characteristics. Cashmere is more sensitive to chemicals than wool. Pashmina is a fine cashmere fiber originally produced in parts of northern India, Kashmir, and Pakistan. Cashmere is sometimes mistaken for shahtoosh, an illegal fiber harvested from slaughtered Tibetan chiru antelopes. The chiru is on the endangered species list. Sometimes, cashmere is blended with less expensive sheep's wool. When labels indicate a blend, no legal problem exists. However, this is a fraudulent practice when the label does not indicate that the product is a blend.

Cashgora is a new fiber resulting from the breeding of feral cashmere goats with Angora goats in New Zealand and Australia. Although the International Wool Textile Organization has adopted cashgora as a generic fiber term, it is not recognized around the world. The fiber is coarser than cashmere and not as lustrous. It is used primarily in less expensive coatings and suits.

Cashmere fiber, because of its high price and high demand by consumers, has been subject to fraud of several kinds. Items labeled 100 percent cashmere or pure Mongolian cashmere may be blended with other fibers such as wool or yak, may be a coarser and lower quality cashmere, or may be a fine wool with no cashmere present. Because of these problems, the Mongolian Fibermark Society has been established to uphold the purity and quality of Mongolian cashmere and ensure that items bearing the label meet strict quality and authenticity standards. In addition, the Federal Trade Commission defines cashmere so labels claiming cashmere content must also meet strict guidelines for fiber size and species.

**Llama and Alpaca**

Llama and alpaca are domesticated animals of the South American branch of the camel family (Figure 16). The fiber from their coats is 8 to 12 inches in length and is noted for its softness, fineness, and luster. The natural colors range from white to light fawn, light brown, dark brown, gray, and black. The fibers are used for apparel, handcrafts, and rugs. Because alpaca is soft, it is often used for apparel. However, it is more difficult to dye than most other specialty wools. For this reason, it is often used in its natural colors. Scales are less pronounced, so felting is not as big a problem as with other wools. Its soft hand, beautiful luster, and good draping characteristics are appreciated by fashion designers. Llama is coarser and most often used for coats, suits, ponchos, and shawls. As with wool, fibers from the younger llama and alpaca are finer and softer.

**Vicuña and Guanaco**

Vicuña and guanaco are rare wild animals of the South American camel family. In the past, the animals were killed to obtain the fiber. Now, they are sheared in a manner similar to that of sheep. Vicuña and guanaco are now protected. Vicuña is one of the softest, finest (13 micron), rarest, and most expensive of all textile fibers. The fiber is short, very lustrous, and light cinnamon in color. Research is under way to produce genetic crosses of alpaca and vicuña. Currently, vicuña are classified as a threatened species. The Peruvian government labels products produced from vicuña with the seal of purity and quality.

**Learning Activity 5**

Use Fabric #38 from your swatch kit. Identify an end use for the fabric and describe its serviceability. Locate a country where this protein fiber could have been produced.
natural protein fibers

Learning Activity 6

Consider the other animal fibers. In terms of sustainability, how do they compare with wool from sheep? Would any of these be competitive with wool in terms of sustainability, production, or properties? Explain your answer.

containing vicuna to guarantee that the animals were captured, sheared alive, released, and will not be sheared again for two years. A large portion of the profit from the sale of vicufa is returned to the villagers. However, poaching continues to be a problem.

Yak

Yak fiber is produced by a large ox found in Tibet and Central Asia. The fiber, which is collected by combing out during the spring molt, is smooth and lustrous. Yak is often used in apparel and rope and tent covers in its native area. Yak fiber is used in the international market because it is mixed with the much more expensive cashmere to extend its use and lower the cost. It is coarser than cashmere and dark brown or black in color.

Silk

Silk is a natural protein fiber. It is similar to wool in that it is composed of amino acids arranged in a polypeptide chain, but it has no cross links. Silk is produced by the larvae of a moth.

According to Chinese legend, silk culture began in 2640 B.C., when Empress Hai Ling Shi became interested in silkworms and learned how to reel the silk and weave it into fabric. Through her efforts, China developed a silk industry and a 3,000-year monopoly. Silk culture later spread to Korea and Japan, westward to India and Persia, and then to Spain, France, and Italy. Silk fabrics imported from China were coveted in other countries; in India, Chinese fabrics were often unraveled and rewoven into looser fabrics or combined with other fibers to produce more yardage from the same amount of silk filament. Several attempts at sericulture were made in the United States, but none were successful. A few villages in Mexico have been producing silk since the Spanish introduced it in the sixteenth century. Today, the major producers of silk are China, India, and Japan.

Silk is universally accepted as a luxury fiber. The International Silk Association of the United States emphasized this by its slogan “Only silk is silk.” Silk has a combination of properties not possessed by any other fiber: It has a dry tactile hand, unique natural luster, good moisture absorption, lively suppleness and draping qualities, and high strength.

The beauty and hand of silk and its high cost are probably responsible for the development of the manufactured fiber industry. Silk is a solid fiber with a simple physical structure. It is this physical nature of silk that some manufactured fibers attempt to duplicate. Most successful are those manufactured fibers with a triangular cross section and fine size.

Production of Silk

Sericulture is the production of cultivated silk, which begins when the silk moth lays eggs on a specially prepared paper (Figure 17). (The cultivated silkworm is usually Bombyx mori.) When the eggs hatch, the caterpillars, or larvae, are fed fresh, young mulberry leaves (Figure 18).
natural protein fibers

After about 35 days and four moltings, the silkworms are approximately 10,000 times heavier than when hatched and are ready to begin spinning a cocoon, or chrysalis case. A straw frame is placed on the tray and the silkworm starts to spin the cocoon by moving its head in a figure eight. The silkworm produces silk in two glands and forces the liquid silk through spinnerets, openings in its head. The two strands of silk are coated with a water-soluble protective gum, sericin. When the silk comes in contact with the air, it solidifies. In 2 or 3 days, the silkworm will spin approximately 1 mile of filament and will completely encase itself in a cocoon (Figure 19). The silkworm then metamorphoses into a moth. Usually the silkworm is killed (stifled) with heat before it reaches the moth stage.

If the silkworm is allowed to reach the moth stage, it is used for breeding additional silkworms. The moth secretes a fluid that dissolves the silk at one end of the cocoon so that it can crawl out. These cocoons cannot be used for filament silk yarns and the staple silk produced from them is less valuable.

To obtain filament silk, the cocoons that have been stifled are sorted for fiber size, fiber quality, and defects, then brushed to find the outside ends of the filaments. Several filaments are gathered together and wound onto a reel. This process, referred to as reeling, is performed in a manufacturing plant called a filature. Each cocoon yields approximately 1,000 yards of usable silk filament. This is raw silk, or silk-in-the-gum, fiber. Several filaments are combined to form a yarn. The operators in the filature must carefully join the filaments so that the diameter of the reeled silk remains uniform in size. Uniformly reeled filament silk is the most valuable (Figure 20).

As the fibers are combined and wrapped onto the reel, twist can be added to hold the filaments together. Adding twist is referred to as throwing, and the resulting yarn is called a thrown yarn. The specific type of yarn and amount of twist relate to the fabric to be produced. The simplest type of thrown yarn is a single, in which three to eight filaments are twisted together to form a yarn. Used for filling yarns in many silk fabrics, singles may have two or three twists per inch.

Staple silk is produced from cocoons in which the filament broke or in which the moth was allowed to mature and come out. It is also produced from the inner portions of the cocoon. This silk is known as silk noils, or silk waste. It is degummed (the sericin is removed) and spun like any other staple fiber, or it is blended with another staple fiber and spun into a yarn. Spun silk is less expensive, less durable, more likely to pill, and of lower quality than filament silk.

Wild silk production is not controlled. Although many species of wild silkworms produce wild silk, the two most common are Antheraea mylitta and Antheraea pernyi. The silkworms feed on oak and cherry leaves in the wild and produce fibers that are much less uniform in texture, color, and diameter. The fiber is most often brown, but yellow, orange, and green also occur. Researchers are investigating the feasibility of producing fabrics from these naturally colored silks.

Since the cocoons are harvested after the moth has matured, the silk cannot be reeled and must be used as spun silk. Tussah silk is the most common type of wild silk. It is coarser, darker, and cannot be bleached. Hence, white and light colors are not available in tussah silk. Tasar is a type of wild silk from India. Some fabrics are sold simply as wild silk. The term "raw silk" is sometimes used incorrectly to describe these fabrics.

Duppioni silk is another type of silk that results when two silkworms spin their cocoons together. The yarn is irregular in diameter with a thick-and-thin appearance. It is used in such linenlike silk fabrics as shantung.
Silk fabric descriptions may include the term momme, the standard way to describe silk fabrics. Momme, pronounced like "mummy" and abbreviated mm, describes the weight of the silk. One momme (momie or mome) weighs 3.75 grams. Most silk fabrics are produced in several weights. Higher numbers describe heavier fabrics. Other terms such as habutai or crêpe describe the yarn and fabric structure. Silk fabrics are often graded for their degree of evenness, fiber or yarn size, and freedom from defects. Grade A refers to the highest grade, only about 10 percent of the silk produced.

Japan is known for its high-quality silks. India produces handwoven wild silks with a pronounced texture. Thailand's handwoven iridescent silks are created by using two yarn colors in weaving the fabric. With over 30 countries producing silk, there is a wide range of silk types and qualities on the market. Pure silk and pure dye silk describe 100 percent silk fabrics that do not contain any metallic weighting compounds.

Physical Structure of Silk
Silk is the only natural filament fiber. It is a solid fiber, smooth but irregular in diameter along its shaft. The filaments are triangular in cross section, with rounded corners (Figure 21). Silk fibers are very fine—1.25 denier/filament (dpf). Wild silks are slightly coarser, with slight striations along the length of the fiber.

Chemical Composition and Molecular Structure of Silk
The protein in silk is fibroin, with 15 amino acids in polypeptide chains. Silk has reactive amino (NH₂) and carboxyl (COOH) groups. Silk has no cross linkages and no bulky side chains. The molecular chains are not coiled, as in wool, but are pleated and packed closely together. Silk's high orientation contributes to its strength. Its elasticity is due to some amorphous areas between the crystalline areas.

Properties of Silk
Consult the fiber property tables when comparing the performance of silk to that of other fibers. Table 4 compares silk and wool.

Aesthetics Silk can be dyed and printed in brilliant colors. Since it is adaptable to a variety of fabrication methods, it is available in many fabric types for interior and apparel uses. Because of cultivated silk's smooth but slightly irregular surface and triangular cross section, its luster is soft, with an occasional sparkle. It is this luster that has been the model for many manufactured fibers. Fabrics made of cultivated silk have a smooth appearance and a luxurious hand. Silk has a smooth, soft hand, but it is not as slippery as many synthetic fibers.

Wild silks have a duller luster because of their coarser size, less regular surface, and the presence of sericin. Fabrics made of wild silk have a more pronounced texture.

In filament form, silk has poor covering power. Before the development of strong synthetic fibers, silk was the only strong filament, and silk fabrics were often treated with metallic salts such as tin, a process called weighting, to produce better drape, covering power, and dye absorption. Unfortunately, these historic weighted silks aged quickly because excessive amounts of metallic salt were used. Figure 22 shows a 19th-century silk bodice that has shattered (disintegrated) as a result of the weighting chemicals added during production. Although this
problem is sometimes referred to as dry rot, it is more commonly known as “shattered silk” by museum specialists. At present, no treatment exists to reduce the damage and save garments with this inherent problem. Silk has \textit{scroop}, a natural rustle, which can be increased by treatment with an organic acid such as acetic or tartaric acid.

\textbf{Durability} Silk has moderate abrasion resistance. Because of its end uses and cost, silk seldom receives harsh abrasion. Silk is one of the strongest natural fibers, with a tenacity of 4.5 g/d dry. It may lose up to 20 percent of its strength when wet. It has a breaking elongation of 20 percent. It is not as elastic as wool because there are no cross linkages to retract the molecular chains. When silk is elongated by 2 percent, its elasticity is only 90 percent. Thus, when silk is stretched even a small amount, it does not return to its original length but remains slightly stretched.

\textbf{Comfort} Silk has good absorbency, with a moisture regain of 11 percent. Silk may develop static cling because of the smoothness of the fibers and yarns and the fabric weight. Silk fabrics are comfortable in summer. Like wool, silk is a poor conductor of heat so that it is comfortably warm in the winter. The weight of a fabric is important in heat conductivity—sheer fabrics are cool, whereas heavy fabrics are warm. Silk is smooth and soft and not irritating to the skin. The density of silk is 1.25 g/cc, producing strong and lightweight silk products. Weighted silk is not as durable as regular silk and wrinkles more readily.

\textbf{Appearance Retention} Silk has moderate resistance to wrinkling. Because silk’s recovery from elongation is low, it does not resist wrinkling as well as some other fibers. Silk fibers do not shrink. Because the molecular chains are not easily distorted, silk swells only a small amount when wet. Fabrics made from true crepe yarns shrink if laundered, but this is due to the yarn structure, not the fiber content.

\textbf{Care} Dry cleaning solvents do not damage silk. Dry cleaning may be recommended for silk items because of yarn types, dyes with poor fastness to water or laundering, or product or fabric-construction methods. Washable silk items can be laundered in a mild detergent solution.

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|}
\hline
Property & Wool & Silk \\
\hline
Abrasion resistance & Moderate & Moderate \\
Breaking tenacity (dry; wet) & Low (1.5 g/d; 1.0 g/d) & High (4.5 g/d; 2.8–4.0) \\
Breaking elongation (dry; wet) & Medium (25%; 35%) & Medium (20%; 30%) \\
Absorbency & High (13–18%) & High (11%) \\
Thermal retention & Excellent & Moderate \\
Specific gravity & Medium (1.32) & Medium (1.25) \\
Resiliency & Excellent & Moderate \\
Elastic recovery at 3% stretch & High (99%) & Medium (90%) \\
Resistance to strong acids & More resistant & More sensitive \\
Resistance to alkalis & Harmed & Harmed \\
Resistance to light & Poor & Poor \\
Fiber length & 1.5–5 inches & Natural filament; available in staple form \\
Fiber fineness (micrometers) & 10–50 & 11–12 \\
\hline
\end{tabular}
\caption{Comparison of Wool and Silk}
\end{table}
with gentle agitation. Since silk may lose up to 20 percent of its strength when wet, care should be taken with wet silks to avoid any unnecessary stress. Silk items should be pressed after laundering. Pure dye silks should be ironed damp with a press cloth. Wild silks should be dry-cleaned and ironed dry to avoid losing sericin and fabric body. Silk interior textiles are generally cleaned by the dry extraction method.

Silk may water-spot easily. Before hand- or machine-washing, test in an obscure place on the item to make sure the dye or finish does not water-spot. Silk can be damaged and yellowed by strong soaps or detergents (highly alkaline compounds) and high temperatures. Chlorine bleaches should be avoided. Cleaning agents containing hydrogen peroxide and sodium perborate are safe to use if the directions are followed carefully.

Silk is resistant to dilute mineral acids and organic acids. A crepelike surface effect may be created by the shrinking action caused by some acids. Silk is weakened and yellowed by exposure to sunlight and perspiration. For this reason, interior textiles of silk should be protected from direct exposure to sunlight. Silks may be attacked by insects, especially carpet beetles. Items should be stored clean because soil may attract insects that do not normally feed on silk.

Weighted silks deteriorate even under ideal storage conditions and are especially likely to break at the folds. Historic items often exhibit a condition known as shattered silk, in which the weighted silk is disintegrating (see Figure 22). The process cannot be reversed.

Table 5 summarizes silk’s performance in apparel and interior textiles.

Environmental Concerns and Sustainability of Silk

Silk is a natural fiber and a renewable resource. Sericulture uses leaves of the mulberry tree. These trees grow in regions where the soil may be too poor to grow other crops or in small and irregular spaces. The trees help retain soil and contribute to the income of small farms. Mulberry trees are severely pruned when the leaves are harvested and the trees do not achieve a natural shape. Since mulberry trees are deciduous, leaves are available for only part of the year and silk production is limited to one generation each year.

**Table 5** Summary of the Performance of Silk in Apparel and Interior Textiles

<table>
<thead>
<tr>
<th>Aesthetics</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luster</td>
<td>Beautiful and soft</td>
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<tr>
<td>Durability</td>
<td>High</td>
</tr>
<tr>
<td>Abrasion resistance</td>
<td>Moderate</td>
</tr>
<tr>
<td>Tenacity</td>
<td>High for natural fibers</td>
</tr>
<tr>
<td>Elongation</td>
<td>Moderate</td>
</tr>
<tr>
<td>Comfort</td>
<td>High</td>
</tr>
<tr>
<td>Absorbency</td>
<td>High</td>
</tr>
<tr>
<td>Thermal retention</td>
<td>Good</td>
</tr>
<tr>
<td>Appearance Retention</td>
<td>Moderate</td>
</tr>
<tr>
<td>Resiliency</td>
<td>Moderate</td>
</tr>
<tr>
<td>Dimensional stability</td>
<td>High</td>
</tr>
<tr>
<td>Elastic recovery</td>
<td>Moderate</td>
</tr>
<tr>
<td>Recommended Care</td>
<td>Dry-clean (apparel) or dry extraction clean (interior textiles)</td>
</tr>
</tbody>
</table>
Learning Activity 7

Use Fabrics #5, 19, 36, and 88 from your swatch kit. Identify an end use for each fabric and describe the serviceability for each product. How would the serviceability change if the fabric were made from cotton or another natural cellulosic fiber? Use Figure 1 and locate a country where these silk fibers might have been produced.

Silkworms are susceptible to disease and changes in temperature. Research is underway to increase silk production by developing disease-resistant varieties, producing artificial diets, and controlling internal environments to induce year-round production. Researchers are also examining the production of naturally colored silks that do not require the use of chemical dyes.

Silkworms are raised for the silk they produce. Most are killed before they have matured in order to harvest filament silk. Because of this, some animal rights activists avoid purchasing or using silk items. Some small quantities of organic, vegetarian, peace, or cruelty-free silk are available from cocoons where the mature silk moth is allowed to leave the cocoon. Wild silk cocoons are harvested after the moth has left the cocoon and are found in open forests with no use of hazardous chemicals. Wild silk is lower in quality than conventional silk because of its staple length.

Silk production is labor-intensive and is concentrated in regions where labor costs are low. When silk prices fall, these regions suffer accordingly. Child labor may be used in producing silk. However, in many areas, silk production also provides economic freedom for women and boosts family income. Efforts to mechanize the production of silkworms could have a pronounced impact on regions that have traditionally relied on hand labor to produce silk.

Silk production makes extensive use of water and other chemicals to clean the fiber and remove sericin. Silk sericin is removed from the silk in a hot water bath (degumming). The waste water is usually discharged into the ground water system without any treatment. Some factories that degum silk have developed water treatment procedures so that the water returned to the environment is clean. Although the use of chemical finishes is relatively low for silk, the use of dyes is high. Dyeing silk requires use of heat, water, dyes, and other chemicals. Environmental regulations are minimal in some parts of the world where silk is processed, and disposal of chemicals is done with little regard for the environment. Although not all silk products require dry cleaning, many do. Dry-cleaning solvents may harm the environment, and their use and disposal are restricted.

Uses of Silk

Silk has a drape, luster, and texture that may be imitated by synthetic fibers, but cannot be duplicated exactly. Because of its unique properties and high cost, silk is used primarily in apparel and interior products. Other factors that contribute to the continued popularity of silk are its appearance, comfort, and strength. Silk is extremely versatile, and it can be used to create a

Learning Activity 8

Is silk a sustainable fiber? Identify the positive and negative aspects of silk in terms of sustainability. Explain your answer.
Learning Activity 9

Compare Tables 2 and 5. Identify end uses where wool would provide better performance and end uses where silk would be better. Are there some end uses where both would be appropriate but provide differences in serviceability? If yes, give examples and explain the serviceability differences.

variety of fabrics, from sheer, gossamer chiffons to heavy, beautiful brocades and velvets. Because of silk's absorbency, it is appropriate for warm-weather wear and active sportswear. Because of its low heat conductivity, it is also appropriate for cold-weather wear. Silk underwear, socks, and leggings are popular due to silk's soft hand, good absorbency, and wicking characteristics. Silk is available in a range of apparel from one-of-a-kind designer garments to low-priced discount store shirts.

Silk and silk blends are equally important in interior textiles. Silk is frequently used in upholstery, wall-covering fabrics, and wall hangings. Some designers are so enamored with silk that they drape entire rooms in it. Silk blends are often used in window-treatment and upholstery fabrics because of their soft luster and drape. The texture and drape of wild and dupioni silks make them ideal for covering ceilings and walls. Occasionally, beautiful and expensive handmade rugs are made of silk. Liners for sleeping bags, blankets, and bed sheets of silk feel warm, soft, and luxurious next to the skin.

Silk is also used in the medical field for sutures, prosthetic arteries, and fibroin-based scaffolds and grafts. The scaffold provides support for regenerating ligaments, tendons, and other bodily connective tissue. It has been successful in restoring full functionality following some injuries.

Spider Silk

For several years, researchers have been intrigued with the dragline silk produced by some spiders of the Nephila and Araneus families because of their exceptional strength, elasticity, and lightweight. This silk can be magnetized, conducts electricity, and is stable to high temperatures. The protein of spider silk is spiderin, but each spider spins several kinds of silk. Capture silk is highly elastic and hydroscopic, while dragline silk is very strong for its fine size. It is difficult to produce quantities of the spider silk for research purposes because spiders are territorial and kill each other before spinning much silk. Spider farms are simply not possible. Researchers are studying the plausibility of using a transgenic silkworm in which some of the silkworm genes have been replaced with spider genes to produce the dragline spider silk. Other researchers have worked with genetically modified goats. The dragline silk would be used in technical products that require exceptional strength and elasticity. Possible applications include civil engineering and road construction applications, protective clothing, and for bone and tendon repair in the medical field.

Identification of Natural Protein Fibers

Natural protein fibers can be identified with a microscope fairly easily. Wool fibers have scales that are visible along the edge and, if the fiber is white or pastel, may be seen throughout the length of the fiber. It is difficult to distinguish among the wool fibers because of their similar