Natural protein fibers are of animal origin: wool and specialty wools are the hair and fur of animals, and silk is the secretion of the silk caterpillar. Figure 1 shows the countries that produce the majority of the natural protein fibers. The natural protein fibers are luxury fibers today. Silk, vicuña, cashmere, and camel hair have always been in this category. Wool is a widely used protein fiber, but production rates have decreased and cost has increased. Some individuals also use the protein fibers from their pet cats and dogs in hand-spun woven or knit textile products.

Protein fibers are composed of various amino acids that have been formed in nature into polypeptide chains with high molecular weights, containing carbon (C), hydrogen (H), oxygen (O), and nitrogen (N). Protein fibers are amphoteric, meaning that they have both acidic and basic reactive groups. The protein of wool is keratin, whereas that of silk is fibroin. The types and percentages of amino acids differ between wool and silk. There are more types of amino acids in wool and fewer types of amino acids in silk. The amino acids in wool tend to have larger molecular side groups compared to those found in silk. This difference means that the wool molecule is bulkier and less compact compared to the silk molecule. Because the side groups in wool are more likely to form temporary bonds with other side groups, wool has better resiliency. Wool contains sulfur while silk does not. Amino acids that contain sulfur are especially attractive to insects, thus explaining why wool is more prone to insect damage. Silk and wool differ in some properties because of their different physical and molecular structures.

To the left is a simple chemical formula for an amino acid, where \( R \) refers to a simple organic functional group.

![Chemical formula for an amino acid](image)

**Figure 1** Countries that produce natural protein fibers.
Table 1  Properties Common to all Protein Fibers

<table>
<thead>
<tr>
<th>Properties</th>
<th>Importance to Consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resiliency</td>
<td>Resist wrinkling. Wrinkles disappear between uses. Fabrics maintain their shape.</td>
</tr>
<tr>
<td>Hygroscopic</td>
<td>Comfortable, protects from humidity in cool, damp climate. Moisture prevents brittleness in carpets.</td>
</tr>
<tr>
<td>Weaker when wet</td>
<td>Handle carefully when wet. Wool loses about 40 percent of its strength and silk loses about 15 percent when wet.</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>Fabrics feel lighter than cellulose fiber of the same thickness.</td>
</tr>
<tr>
<td>Harmed by alkali</td>
<td>Use neutral or only slightly alkaline soap or detergent. Perspiration weakens the fiber.</td>
</tr>
<tr>
<td>Harmed by oxidizing agents</td>
<td>Chlorine bleaches damage fiber so should not be used. Sunlight causes white fabrics to yellow.</td>
</tr>
<tr>
<td>Harmed by dry heat</td>
<td>Wool becomes harsh and brittle and scorches easily with dry heat. Use steam. White silk and wool will yellow.</td>
</tr>
<tr>
<td>Flame resistance</td>
<td>Do not burn readily and self-extinguish; have odor of burning hair; form a black, crushable ash.</td>
</tr>
</tbody>
</table>

Learning Activity 1

Examine Table 1. Explain these properties in terms of a jacket to wear in an office building. How do these terms relate to the concept of serviceability?

Protein fibers have some common properties because of their similar chemical composition (Table 1). These fibers absorb moisture without feeling wet; they are hygroscopic. This phenomenon explains why items made from protein fibers are comfortable to use. Hygroscopic fibers minimize sudden temperature changes at the skin. In the winter, when people go from dry indoor air into damp, cold outdoor air, wool absorbs moisture and generates heat, insulating the wearer from the cold.

Wool

Because of wool garments and interior textiles' high initial cost and the cost of their care, many consumers consider them to be investments. These factors have encouraged the substitution of acrylic, polyester, or wool/synthetic blends in many products. However, wool's combined properties are not equaled by any manufactured fiber: ability to be shaped by heat and moisture, good moisture absorption without feeling wet, excellent heat retention, water repellency, flexibility, and flame-retardancy.

Wool was one of the earliest fibers to be spun into yarns and woven into fabric. Wool was one of the most widely used textile fibers before the Industrial Revolution. Sheep were probably among the first animals to be domesticated. The fleece of primitive sheep consisted of a long, hairy outercoat (kemp) and a light, downy undercoat. The fleece of present-day domesticated sheep is primarily the soft undercoat. The Spanish developed the Merino sheep, whose fleece contains no kemp fiber. Some kemp is still found in the fleece of all other sheep breeds.

Sheep raising on the Atlantic seaboard began in the Jamestown, Virginia, colony in 1609 and in the Massachusetts settlements in 1630. From these centers, the sheep-raising industry spread rapidly. In 1643 in the Massachusetts Bay colony, the New England textile industry got its start when English wool combers and carders began to produce and finish wool fabric. Following the U.S. Civil War, sheep production expanded with the opening of free grazing lands...
west of the Mississippi. By 1884, the peak year, 50 million sheep were found in the United States; the number of sheep has declined steadily since then.

### Production of Wool

In 2007, wool was produced by Australia (22.5 percent), New Zealand (18.8 percent), China (18.8 percent), and Eastern Europe (10.0 percent). The United States ranked tenth, with only 0.8 percent of world production. Worldwide production was 4,678 million pounds of raw wool fiber.

**Merino** sheep produce the most valuable wool (Figure 2). Australia produces about 43 percent of the Merino wool. Good-quality fleeces weigh 15 to 20 pounds each. Merino wool is 3 to 5 inches long and very fine. It is used to produce high-quality, long-wearing products with a soft hand and luster and good drape.

Fine wool is produced in the United States by four breeds of sheep: Delaine-Merino, Rambouillet, Debouillet, and Targhee. The majority of this fine wool is produced in Texas and California. It is 2½ inches long. These fine wools are often used for products that compete with higher-priced Merino wools.

The greatest share of U.S. wool production is of medium-grade wools removed from animals raised for meat. These wools have a larger diameter than the fine wools and a greater variation in length, from 1½ to 6 inches. They are used for products such as carpeting, where the coarser fiber contributes high resiliency and good abrasion resistance. The fifteen breeds of sheep commonly found in the United States vary tremendously in appearance and type of wool produced. Sheep are raised throughout the United States but most are raised in the west.

Sheep are generally sheared once a year, in the spring. The fleece is removed in just minutes with power shears that look like large barber's shears. A good shearer can handle 100 to 225 sheep per day. The fleece is removed in one piece with long, smooth strokes, beginning at the legs and belly. After shearing, the fleece is folded together and bagged to be shipped to market.

As alternatives to shearing, both a chemical feed additive and an injection have been developed. When digested, the feed additive makes the wool brittle. Several weeks later, the fleece can be pulled off the sheep. The injection causes the sheep to shed the fleece a week or so later. Both alternatives decrease shearing costs.

Newly removed wool is **raw wool** or **grease wool**, which contains between 30 and 70 percent by weight of such impurities as sand, dirt, grease, and dried sweat (sweat). Removing these impurities produces **clean** or **scoured wool**. The grease is purified to lanolin and used in creams, cosmetics, soaps, and ointments.

Grading and sorting are two marketing operations that group wools of like character together. **Grading** is evaluating the whole fleece for fineness and length. **Sorting** is separated into sections of fibers of different quality. The best-quality wool comes from the sides, shoulders, and back; the poorest wool comes from the lower legs. Wool quality helps determine use. For example, fine wool works well in a lightweight worsted fabric, while coarse wool works well in carpets. Fineness, color, crimp, strength, length, and elasticity are characteristics that vary with the breed of the sheep. However, genetic engineering of sheep may alter the physical characteristics and performance properties of wool.

### Types and Kinds of Wool

Many types of wool are used in yarns and fabrics. Although breeds of sheep produce wools with different characteristics, labels on wool products rarely state that information; the fiber is

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*Figure 2* Merino sheep.
simply identified as wool. The term wool legally includes fiber from such animals as sheep, Angora and Cashmere goats, camel, alpaca, llama, and vicuña.

Sheared wool is removed from live sheep. Pulled wool is taken from the pelts of meat-type sheep. Recycled wool is recovered from worn apparel and cutters’ scraps. Lamb’s wool comes from animals less than 7 months old. This wool is finer and softer. It has only one cut end; the other end is the natural tip (Figure 3). Lambs’ wool is usually identified on a label.

Wool is often blended with less expensive fibers to reduce the cost of the fabric or to extend its use. The Federal Trade Commission defines label terms for wool garments as follows:

- **Virgin wool**—wool that has never been processed. Use of the single term wool implies a virgin wool and is a helpful marketing tool.
- **Wool**—new wool or wool fibers reclaimed from knit scraps, broken thread, and soles. (Nails are short fibers that are removed in making worsted yarns.)
- **Recycled wool**—scraps of new woven or felted fabrics that are garnetted (shredded) back to the fibrous state and reused. Shoddy wool comes from old apparel and rags that are cleaned, sorted, and shredded. Recycled wool may be blended with new wool before being respun and made into fabrics.

Recycled wool is important in the textile complex. However, these fibers may be damaged by the mechanical action of garnetting and/or wear. The fibers are not as resilient, strong, or durable as new wool, yet the fabrics made from them perform well. The terms recycled wool and virgin wool on a label do not refer to the quality of the fiber but to the past use of the fiber.

Quality of wool is based on fiber fineness, length, scale structure, color, cleanliness, and freedom from defects caused by environment or processing. The coarse fiber content of wool may be determined because the coarser fibers contribute to the prickle that may occur when wearing wool garments. The best-quality wools are white, clean, long, free of defects and coarse fibers, and contain small-diameter fibers with a regular scale structure. The Federal Trade Commission also defines superfine wools so labels claiming a superfine wool content must meet strict guidelines for fiber size.

**Physical Structure of Wool**

**Length** The length of Merino wool fibers ranges from 1½ to 5 inches, depending on the animal and the length of time between shearings. Long, fine wool fibers, used for worsted yarns and fabrics, have an average length of 2½ inches. Worsted refers to a compact yarn and implies longer fibers and greater uniformity of fiber length after it undergoes a combing process. The shorter fibers, which average 1½ inches in length, are used in woolen fabrics. Woolen describes a softer and more loosely twisted yarn and implies shorter, less uniform in length, and less parallel fibers. Some sheep breeds produce coarse, long wools (5 to 15 inches in length) used in specialty and hand-crafted fabrics.

The diameter of wool fiber varies from 10 to 50 micrometers. Merino lamb’s wool may average 15 micrometers in diameter. The wool fiber has a complex structure, with a cuticle, cortex, and medulla (Figure 4).

**Medulla** When present, the medulla is a microscopic honeycomb-like core containing air spaces that increase the insulating power of the fiber. It may appear as a dark area when seen through a microscope, but is usually absent in fine wools.
Cortex The cortex is the main part of the fiber. It is made up of long, flattened, tapered cells with a nucleus near the center. In natural-colored wools, the cortical cells contain melanin, a colored pigment.

The cortical cells on the two sides of the wool fiber react differently to moisture and temperature. These cells are responsible for wool’s unique three-dimensional crimp, in which the fiber bends back and forth and twists around its axis (Figures 5 and 6). Crimp may be as high as 30 per inch for fine Merino wool to as low as 1 to 5 per inch for low-quality wool.

This irregular lengthwise waviness gives wool fabrics three important properties: cohesiveness, elasticity, and loft. Crimp helps individual fibers cling together in a yarn, which increases the strength of the yarn. Elasticity is increased because crimp helps the fiber act like a spring. As force is exerted on the fiber, the crimp flattens so that the fiber becomes straighter. Once the force is released, the undamaged wool fiber gradually returns to its crimped position. Crimp also contributes to the loft or bulk that wool yarns and fabrics exhibit throughout use.

Figure 4 Physical structure of wool fibers.

Figure 5 Natural crimp in wool.

Figure 6 Three-dimensional crimp of wool fiber.
Wool is a natural bicomponent fiber; it has two different cell types or two components with slightly different properties in the cortex. This bicomponent nature is best illustrated by describing how wool reacts to moisture. One side of the fiber swells more than the other side, decreasing the fiber’s natural crimp. When the fiber dries, the crimp returns.

Wool can be compared to a giant molecular coil spring. It has excellent resiliency when the fiber is dry and poor resiliency when it is wet. If dry wool fabric is crushed, it tends to spring back to its original shape when the crushing force is released. Wool can be stretched up to 30 percent longer than its original length. Recovery from stretching is good, but it takes place more slowly when the fabric is dry. Since steam, humidity, and water hasten recovery, wool items lose wrinkles more rapidly when exposed to a steamy or humid environment.

**Cuticle** The cuticle consists of an epicuticle and a dense, nonfibrous layer of scales. The epicuticle is a thin, nonprotein membrane that covers the scales. This layer gives water repellency to the fiber but is easily damaged by mechanical action. In fine wools, the scales completely encircle the shaft and each scale overlaps the bottom of the preceding scale, like parts of a telescope. In medium and coarse wools, the scale arrangement resembles shingles on a roof or scales on a fish (Figure 7). The free edges of the scales project outward and point toward the tip of the fiber. The scales contribute to wool’s abrasion resistance and felting property, and they can irritate sensitive skin.

**Felting**, a unique and important property of wool, is based on the structure of the fiber. Under mechanical action—combining agitation, friction, and pressure with heat and moisture—adjacent wool fibers move rootward and the scale edges interlock. This prevents the fiber from returning to its original position and results in shrinkage, or felting, of the fabric. Felting refers to the ability of fibers to mat together.

The movement of the fibers is speeded up and felting occurs more rapidly under severe conditions. Wool items can shrink to half their original size. Lamb’s wool felts more readily than other wools. In soft, knit fabrics the fibers are more likely to move, so these fabrics are more susceptible to felting than are the firmly woven fabrics. While felting is an advantage in making felt fabric directly from fibers without spinning or weaving, it makes the laundering of wool more difficult. Treatments to prevent felting shrinkage are available.

**Chemical Composition and Molecular Arrangement of Wool** Wool fiber is a cross-linked protein called keratin. It is the same protein that is found in horns, hooves, and in human hair and fingernails. Keratin consists of carbon, hydrogen, oxygen, nitrogen, and sulfur. These

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### Learning Activity 2

**Supplies needed:**

- Wool fiber, wool yarn, or wool fabric. Make sure it has not been finished to be machine washable. Some wool yarn is marketed as feltable.
- Paper or fabric towels
- Squirt bottles with water and shampoo or detergent added

Take a small handful of wool fiber, a 6-inch piece of wool yarn, or a piece of wool fabric. Wet the wool with water with shampoo or detergent added to speed wetting. Work the wool with your hands rolling it back and forth or around. After several minutes, examine the result. Is it felted? Can you separate the individual fibers? Explain what happened.
natural protein fibers

combine to form over 17 different amino acids. Five amino acids are shown in Figure 8. The flexible molecular chains of wool are held together by natural cross links—cystine (or sulfur) linkages and salt bridges—that connect adjacent molecules.

Figure 8 resembles a ladder, with the cross links analogous to the crossbars of the ladder. This simple structure can be useful in understanding some of wool's properties. Imagine a ladder that is pulled askew. When wool is pulled, its cross links help it recover its original shape. However, if the cross links are damaged, the structure is destroyed and recovery cannot occur.

Cystine linkages
Contribute to:
- Strength
- Lateral resistance
React with:
- Alkalis
- Bleaches
- Heat
- "Permanent set" agents
- Non-felting agents
- Moth-proofing agents

Hydrogen bonds
Contribute to:
- Strength
- Elasticity
- "Temporary set"
React with:
- Moisture
- Alkalis
- Bleaches
- Heat
- Sunlight
- "Permanent set"
- Non-felting agents
- Moth-proofing agents

Salt bridge
Contributes to:
- Strength
React with:
- Acids
- Dyes

Figure 8 Structural formula of the wool molecule.
A more realistic model of wool's molecular structure would show this ladder-like structure alternating with a helical structure. About 40 percent of the chains are in a spiral formation, with hydrogen bonding occurring between the closer parts. The ladder-like formation occurs at the cystine cross links or where other bulky amino acids meet and the chains cannot pack closely together. The spiral formation works like a spring and contributes to wool's resiliency, elongation, and elastic recovery. Figure 9 shows the helical structure of wool.

The cystine linkage is the most important part of the molecule. Any chemical, such as alkali, that damages this linkage can destroy the entire structure. In finishing wool, the linkage can be broken and then reformed. Pressing and steaming can produce minor modifications of the cystine linkage. Careless washing and exposure to light can destroy the links and damage the fiber.

Shaping of Wool Fabrics Wool fabrics can be shaped by heat and moisture—a definite plus in producing wool products. Puckers can be pressed out; excess fabric can be eased and pressed flat or rounded as desired. Pleats can be pressed with heat, steam, and pressure, but they are not permanent to washing.

Hydrogen bonds are broken and reformed easily with steam pressing. The newly formed bonds retain their pressed-in shape until exposed to high humidity, when the wool returns to its original shape.

Properties of Wool

Aesthetics Because of its physical structure, wool contributes loft and body to fabrics. Wool sweaters, suits, carpets, and upholstery are the standard "looks" by which manufactured fiber fabrics are measured.

Wool has a matte appearance. Shorter wool fibers are sometimes blended with longer wool fibers, specialty wools such as mohair, or other fibers to modify the fabric's luster or texture.

Drape, luster, texture, and hand can be varied by choice of yarn structure, fabric structure, and finish. Sheer wool voiles, medium-weight printed wool challis, medium-weight flannels and tweeds, heavy-weight coating, upholstery fabrics, and wool rugs and carpets demonstrate the range of possibilities.

Durability Wool fabrics are durable. Their moderate abrasion resistance stems from the fiber's scale structure and excellent flexibility. Wool fibers can be bent back on themselves 20,000 times without breaking, as compared with 3,000 times for cotton and 75 times for rayon. Atmospheric moisture helps wool retain its flexibility. Wool carpets, for example, become brittle if the air is too dry. The crimp and scale structure of wool fibers make them so cohesive that they cling together to make strong yarns.

Wool fibers have a low tenacity, 1.5 g/d dry and 1.0 g/d wet. The durability of wool fibers relates to their excellent elongation (25 percent) and elastic recovery (99 percent). When stress is put on the fabric, the crimped fibers elongate as the molecular chains uncoil. When stress is removed, the cross links pull the fibers back almost to their original positions. The combination of excellent flexibility, elongation, and elastic recovery produces wool fabrics that can be used and enjoyed for many years.
Comfort. Wool is more hygroscopic than any other fiber, with a moisture regain of 13 to 18 percent under standard conditions. In a light rain or snow, wool resists wetting and the water runs off or beads on the fabric surface. This should be no surprise since wool evolved to protect sheep from severe weather. Wool dries slowly enough that the wearer is more comfortable than in any other fiber.

Wool is a poor conductor of heat, so warmth from the body is not dissipated readily. Outdoor sports enthusiasts have long recognized the superior comfort provided by wool. Wool's excellent resiliency contributes to its warmth. Since wool fibers recover well from crushing, fabrics remain porous and capable of trapping air. This "still" air is an excellent insulator because it keeps body heat close to the body.

Some people are allergic to the chemical components of wool; they itch, break out in a rash, or sneeze when they touch wool. For others, the harsh edges of coarse, low-quality wools are irritating and uncomfortable.

Wool has a medium specific gravity (1.32). People often associate heavy fabrics with wool since it is used in fall and winter wear, when the additional warmth of heavy fabrics is desirable. Lightweight wools are very comfortable in the changeable temperatures of spring and early fall.

One way to compare fiber densities is to think of blankets. A winter blanket of wool is heavy and warm. An equally thick blanket of cotton would be even heavier (cotton has a higher density), but not as warm. A winter blanket of acrylic would be lighter in weight (acrylic has a lower density than either wool or cotton). Personal preferences will help determine which fiber to choose.

Appearance Retention. Wool is a very resilient fiber. It resists wrinkling and recovers well from wrinkles. (It wrinkles more readily when wet.) Wool maintains its shape fairly well during normal use. Wool apparel may be lined to help maintain garment shape.

When wool fabrics are dry-cleaned, they retain their size and shape well. When wool items are hand-washed, they need to be handled carefully to avoid shrinkage. Follow the care instructions for washable wools.

Wool has an excellent elastic recovery—99 percent at 2 percent elongation. Even at 20 percent elongation, recovery is 63 percent. Recovery is excellent from the stresses of normal usage. Wool carpet maintains an attractive appearance for years.

Care. Wool does not soil readily, and the removal of soil from wool is relatively simple. Grease and oils do not spot wool fabrics as readily as with fabrics made of other fibers. Wool items do not need to be washed or dry-cleaned after every use. Layer wool garments with washable ones next to the skin to decrease odor pickup.

Gentle use of a firm, soft brush not only removes dust but also returns matted fibers to their original position. Damp fabrics should be dried before brushing. Garments require a rest period between wearings to recover from deformations. Hang the item in a humid environment or spray it with a fine mist of water to speed recovery.

Wool is very susceptible to damage when it is wet. Its wet tenacity is one-third lower than its relatively low dry strength. When wet, its breaking elongation increases to 35 percent and resiliency and elastic recovery decrease. The redeeming properties of dry wool that make it durable in spite of its low tenacity do not apply when it is wet, so handle wet wool very gently.

Dry cleaning is the recommended care method for most wool items. Dry cleaning minimizes potential problems that may occur during hand or machine washing. Incorrect care procedures can ruin an item.
Some items can be hand-washed if correct procedures are followed. Use warm water that is comfortable to the hand. Avoid agitation; squeeze gently. Support the item, especially if it is knitted, so it does not stretch. Air-dry it flat. Do not machine or tumble dry or felting will occur. Woven or knitted items that are labeled “machine-washable” are usually blends or have been finished so they can be laundered safely. Special instructions for these items often include use of warm or lukewarm water, a gentle cycle for a short period of time, and drying flat.

Chlorine bleach, an oxidizing agent, damages wool. One can verify this by putting a small piece of wool in fresh chlorine bleach and watching the wool dissolve. Wool is also very sensitive to alkalis, such as strong detergents. The wool reacts to the alkali by turning yellow; it then becomes slick and jelly-like and finally dissolves. If the fabric is a blend, the wool in the blend disintegrates, leaving only the other fibers.

Wool is attacked by moth larvae and other insects. Regular use of mothballs or crystals is discouraged due to the toxic nature of these pesticides. However, they should be used when evidence of insects is apparent, such as when moths or traces of larvae are seen. Moth larvae also eat, but do not digest, any fiber that is blended with wool. Unless mothproofed, wool fabrics should be stored so that they will not be accessible to moths. Wool fabrics should be cleaned before storage.

Wool burns very slowly and is self-extinguishing. It is normally regarded as flame-resistant. This is one of the reasons why wool is so popular with interior designers. However, when wool is used in public buildings, a flame-retardant finish may be needed to meet building code requirements.

Table 2 summarizes wool's performance in apparel and interior textiles.

### Learning Activity 3

Use Fabrics #11, 39, 61, 66, and 69 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 of production for each of the wool fabrics. Remember, coarser wools may not be imported from Australia or New Zealand.

### Table 2 Summary of the Performance of Wool in Apparel and Interior Textiles

| Aesthetics | Variable |
| Luster | Matte |
| Durability | High |
| Abrasion resistance | Moderate |
| Tenacity | Poor |
| Elongation | High |
| Comfort | High |
| Absorbency | High |
| Thermal retention | High |
| Appearance Retention | High |
| Resiliency | High |
| Dimensional stability | Poor |
| Elastic recovery | Excellent |
| Recommended Care | Dry-clean (apparel) |
Environmental Concerns and Sustainability of Wool

Since wool is a natural fiber, many consumers believe it is environmentally friendly. Although wool can be viewed as a renewable resource, it is not produced without any impact on the environment. Sustainable management of natural and physical resources is a challenge for sheep growers. Sheep graze pastures so closely that soil erosion can occur if care is not taken to avoid overgrazing. Disposal of animal waste is another concern. Sheep manure is frequently spread over the ground to return nutrients to the soil. However, excessive applications can create problems during spring thaw or after heavy rains with runoff contaminated with the manure. In addition, sheep producers have traditionally opposed programs that contribute to the survival of wolves and other natural predators. Other sustainability issues relate to the treatment of sheep, shearing practices, and health and back problems associated with shearing hundreds of sheep daily.

Sheep are susceptible to some diseases that can be transmitted to humans. Most of these diseases are of concern only to sheep producers; consumers of wool products are not at risk. However, customs officials and importers check imported wools from some countries for diseases that can be transmitted via contaminated fibers. Fibers contaminated in this way will not be imported. Consumers should not be concerned with imported items purchased in the United States, but they should exercise caution when purchasing wool products in some other countries.

Sheep are also susceptible to parasitic infections. Treatment to prevent the infection makes use of pesticides, either through injection or as a surface application as either a pour-on liquid treatment or the animal is dipped in a bath. If the liquid pesticide is disposed of improperly, contamination of lakes, streams, and other water systems can occur. The pesticides used are highly toxic to aquatic life.

Organic wool is from sheep that are fed organically grown feed, graze on land not treated with pesticides, and not dipped in synthetic pesticides. Only a small percentage of the wool produced is organic, but interest in organic wool is growing.

Merino sheep have wrinkled skin, especially around the tail area. These wrinkles tend to collect moisture and urine and are attractive areas for flies to lay eggs. To prevent this problem, ranchers sometimes remove the excess skin from this area. This treatment is more common with organic wool since the treatment is used to control flies because insecticides are prohibited with organic wool. Animal right activists object to this practice and to the shearing of fiber from any animal.

Because of concerns about how sheep and other animals are treated, some companies use barcodes to enable consumers to trace the path wool takes from the grower through the production process. Criteria regarding animal health and welfare, long-term environmental respect, and fiber quality standards must be met for products that bear these codes. Promotional organizations accredit growers who meet specific standards related to fiber quality and animal welfare; environmental, social, and economic values; and trace the wool from grower through manufacturer. Some of these wools are organic, while others are free-range (meaning that the sheep graze in open pastures).

Other environmental issues relate to the intensive use of water, energy, and chemicals to clean the greasy wool fiber, produce the fabrics, and finish and dye them. Wool is the only fiber that requires hot water or solvent cleaning before being processed into a yarn. The cleaning process produces wool grease sludge with a high pollution index. While the wool grease is usually reclaimed for use as lanolin, pesticides applied to the wool may remain in the grease. When an organic solvent is used in cleaning raw wool, it is reclaimed and recycled.