Where There's Wool, There's a Way

Maurice Shelton and Chris Lupton

The ancestors of modern U.S. sheep produced a long coat of hair and a short inner insulating coat of wool. Through the years, sheep have been bred and selected to eliminate the hair and to produce relatively long wool fibers.

Once upon a time, prehistoric peoples covered themselves with pelts taken from the animals they killed for food. This system had its disadvantages, not the least of which was that the pelt was a one-shot deal. And an animal large enough to provide a commodious winter coat might also be large (and bad-tempered) enough to put up a painful fight. To the rescue came the sheep, along with the goat, which were among the first animals to be domesticated ten to twelve thousand years ago. In Babylon ("land of wool"), woven woolen garments appeared as early as 4,000 B.C.

Our ancestors were glad to find that raw material for clothes could be obtained without killing the animal source. And the roots of today's multimillion-dollar fashion industry can be traced to the primitive arts of spinning, weaving, and tailoring needed to produce garments from sheep's wool.

People keeping sheep found themselves managing a renewable resource rather than hunting and foraging, a major step on the road to civilization.

U.S. Wool Production Sags

Today's total annual world production of wool weighs in at 6.4 billion pounds. Wool refers to the fiber produced by sheep, though a few other animals, such as the goat (Angora and Cashmere), Angora rabbit, llama, alpaca, and vicuña, have been exploited for fiber production. Since a high percentage of the world's wool is produced in the Southern Hemisphere, but most is used in the Northern Hemisphere, wool is an important commodity in world trade. Australia, New Zealand, and Argentina rank as the world's top wool exporters.

The U.S. is not a leader in wool production, and totals continue to drop. In 1983, the U.S. imported about 78 million pounds of cleaned wool. An additional 150 million pounds of wool were imported after some type of processing. We import 80% of the wool used in this country, which seems somewhat ironic at a time when U.S. agriculture overproduces many other commodities.

The U.S. does not lack land adapted for sheep production. The sheep, a ruminant animal, thrives on rangeland that is ill suited for crops or commercial timber. This includes large areas of the West and marginal lands in other areas. Texas, California, Tweeds, plaids, worsteds, fleecy sweaters... Sheep's wool provides high quality material for clothing nonwooly humans.

Colorado, and Wyoming are the nation's top sheep-producing states.

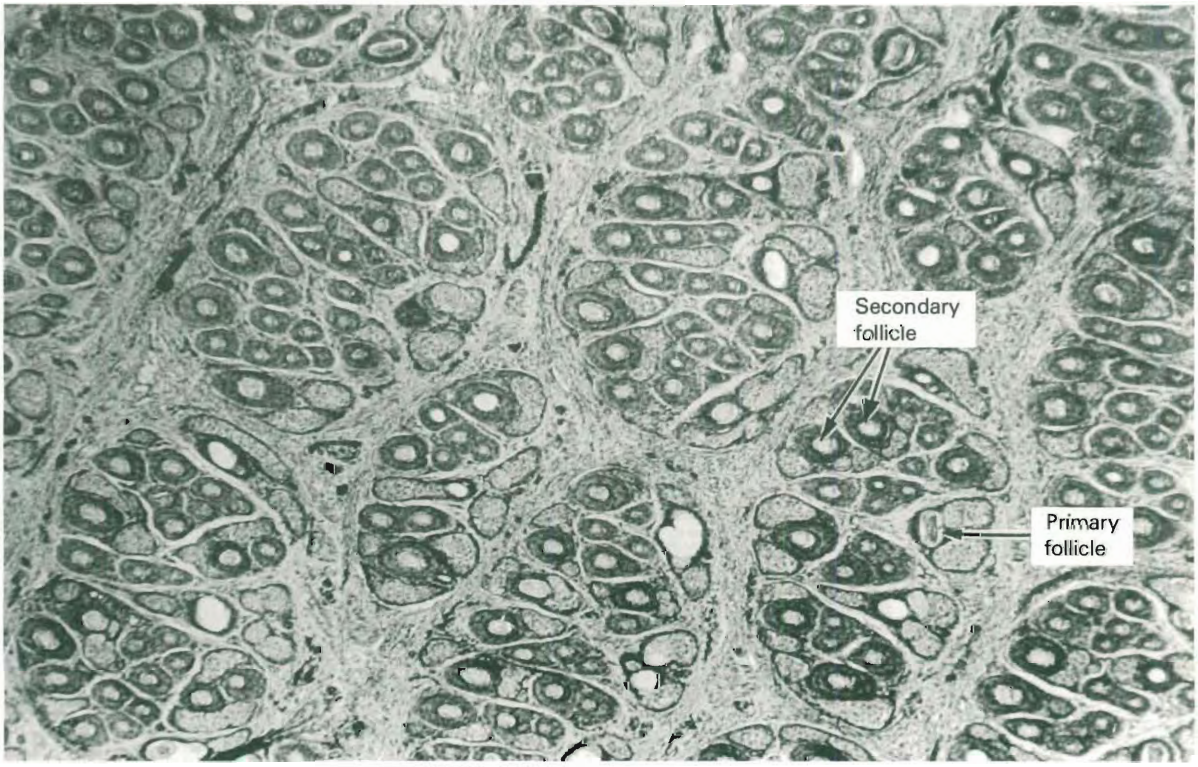
Although sheep will thrive in large areas of the range states, the deficiency in wool production in the U.S. is a matter of economics. The income from wool alone cannot support the sheep industry. Mutton is not one of the most popular meats in the U.S., and predation along with high labor and feed costs make lamb production in range areas an expensive business.

In the future, wool production may begin to look more attractive economically because it depends on renewable natural resources. Synthetic fibers, wool's chief competitors, are now less costly than wool, but they are made from increasingly expensive, dwindling supplies of fossil fuel. Sheep and wool production are also well suited to conservation agriculture.

How the Marvelous Wool Factory Evolved

The original ancestors of modern sheep bore two distinct layers of fiber. A long, coarse outer coat covered and protected a short, insulating undercoat of soft, fine fibers. Since finer yarns and more comfortable clothing can be made from the soft fibers, sheep were bred to produce the delicate strands in greater proportions and greater amounts. The Merino sheep and its genetic kin are the prime offspring of this process.

All animal fibers grow from small cavities or follicles in the skin. Fibers occur in follicle bundles which normally consist of three primary follicles and a varying number of secondary follicles. The primary follicles produce the coarse hair, and the secondary follicles produce the inner coat of fine hair



Photomicrograph of the surface of the skin of a sheep showing the primary and secondary follicles. Fibers occur in bundles that normally consist of three primary follicles and a variable number of secondary follicles.

Sheep shearing is a labor-intensive operation that requires both skill and hard work. Here sheep shearing is being demonstrated at a ranch near Vail, Colorado.

or down. Animals such as the Merino that are bred to produce a fine grade of wool grow coats consisting almost entirely of a well-developed inner layer derived from the secondary follicles. Breeding and selecting animals for fiber production is relatively simple, since their fleece is easily observed or measured. But the realization of genetic change still takes time.

Sheep Shearing Time and Beyond

Sheep are normally shorn in the spring, but shearing twice yearly is not unusual. The shorter wools from biannual shearing are often used for making felt (a cloth of matted wool, sometimes with other fibers, that is worked into a compact material by intermittent pressure in the presence of moisture). Shearing involves skill as well as hard physical labor. (Despite their docile temperament, the sheep don't lie down and wait patiently for the clippers!) Attempts have been made to develop alternative methods, such as chemicals or drugs that cause the wool to shed, or laser or robot shearing. None of these have replaced the basic shearing technique handed down from Biblical times, although electric clippers are now widely used.

After shearing, wool is graded and sorted. Grading involves separating the fleeces (wool from individual animals) according to the diameter and length of the fibers. Individual fleeces are sorted according to different qualities. Inferior portions of short, coarse, or stained wool are removed. Domestic lots of wool are sold after the buyer assesses them. Should disputes arise between the buyer and seller, specific measurements can be made. Properties that can be quantified include vegetable content and fiber yield, length, and diameter. Lots of wool graded on these bases are purchased by the textile industry to meet specific needs.

Cleaning Up the Act

The first step in converting wool into fabric is scouring or washing. In the early days, wool was scoured in small amounts to aid hand spinning. Removal of the grease (lanolin), dirt, and suint (sheep sweat) was not critical to hand spinners. They actually preferred to have some grease remaining in the wool when they were preparing yarn for water repellant outerwear.

With the advent of mechanized yarn and fabric production, scouring evolved into a specialized process set apart from the rest of the textile industry. The basic technology has changed little in the last 50 years. Wool grease is transferred from the fibers to an aqueous emulsion with the aid of elevated water temperatures (120-140°F) and soap. Recently, more efficient emulsifiers, such as synthetic nonionic detergents, have replaced soap in this process. Most of the other recent innovations have involved reducing the quantity of water used for efficient scouring. This results in both water and energy savings and allows for more efficient grease removal.

Treatment of wool scouring liquors has also resulted in specialized technology. Since emulsions thick with wool grease and saturated with suint and other soluble impurities do not respond well to traditional micro-organism treatment, an emulsion "cracking" process utilizing sulfuric acid was first developed to break the emulsion and allow the grease to float to the surface where it could be relatively easily removed. Lanolin reclaimed in this way became a significant sideline for commercial wool scourers. Other developments in this area have included separation of grease by centrifugation, filtration, and more recently, distillation techniques. It should be pointed out that nowadays effluent treatment is necessitated by antipollution legislation and not by economic gain from the sale of wool grease. This legislation is also largely responsible for the current trend to establish scouring and preliminary manufacturing processes in less densely populated areas where the wool originates.

Properties of Wool Fiber Determine Usage

Fine wool fibers are composed of a cuticle and a cortex. Cigar-shaped cortical cells composed of microfibrils make up the cortex. This arrangement gives strength, resilience, and absorbency to wool fabric.

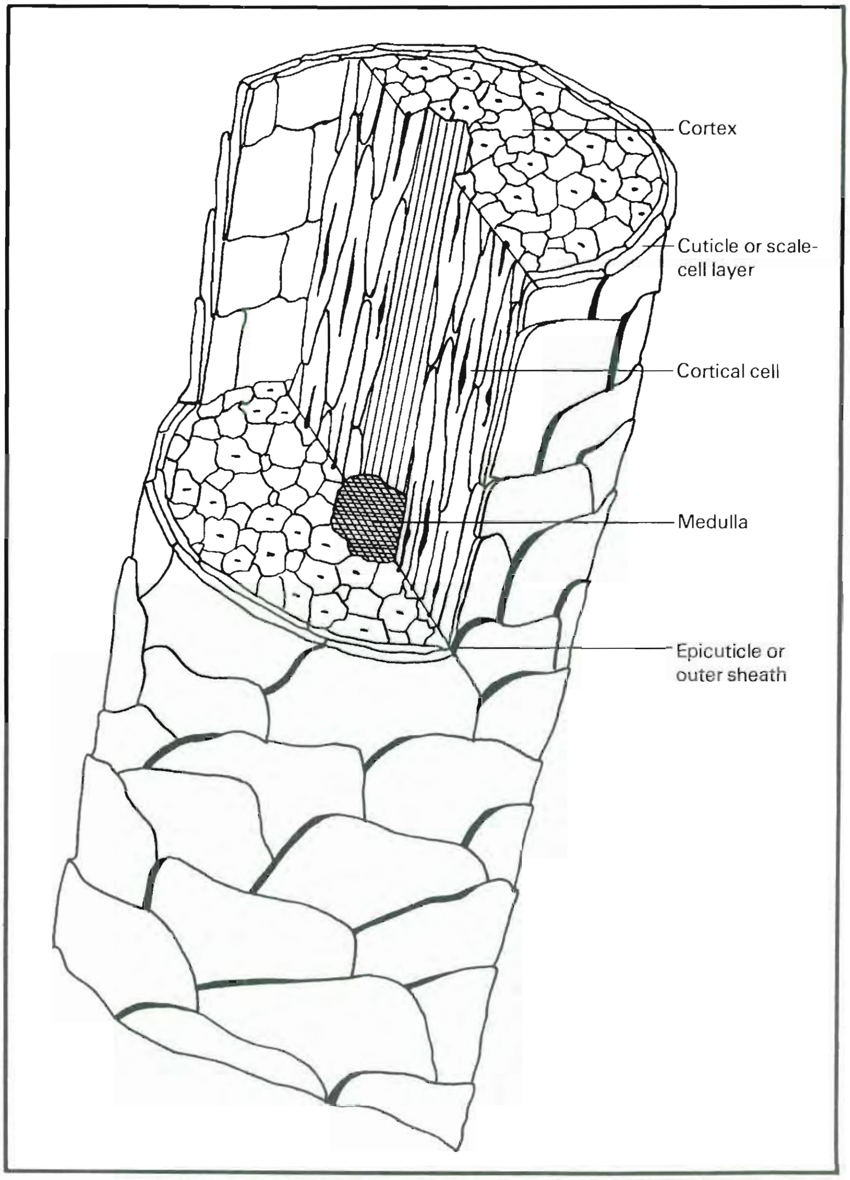
The cuticle is a nonfibrous outer layer of overlapping scales that are responsible for the excellent abrasion resistance and water repellance of wool. As a result of the scales, the fibers become interlocked during the felting process. This unique characteristic explains why wool (but not hair, cotton, or synthetic fibers) can be made into felts and partially felted (woolen) clothing.

Coarse fibers also contain a medulla. The medulla consists of a core of air-filled cells. This characteristic improves the wool's insulating capacity. Outer thermal garments are best made from coarse, medullated fibers; light-weight suitings are not.

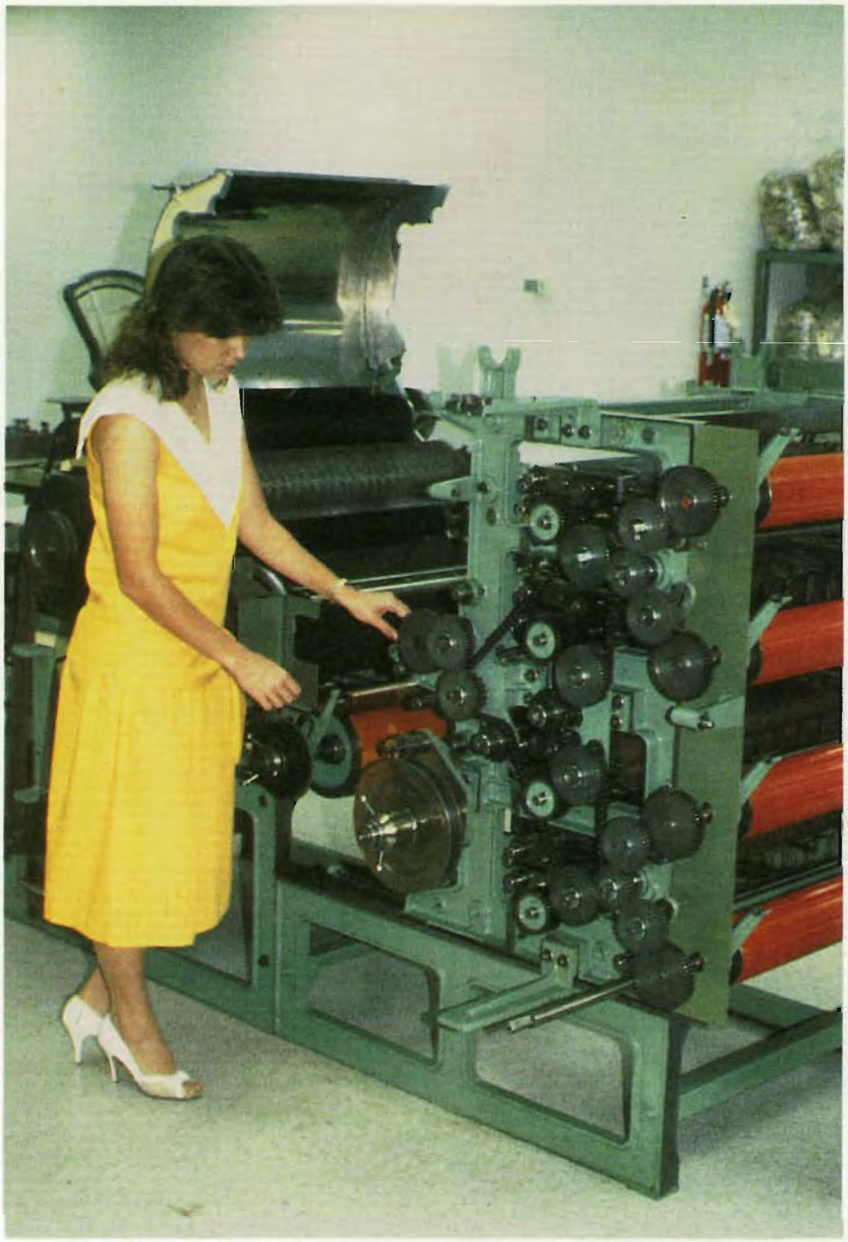
The slightly elliptical wool fibers range in diameter from less than 16 to more than 40 microns, and may range in length from 2 to 30 centimeters (about 1 to 12 inches). These variations in length have resulted in two separate systems for converting scoured wool into yarn.

The more complex *worsted* system uses the longer fibers. They are parallelized by a process known as gilling (or pin drafting), combed to remove short fibers, and spun into yarns used to make fine worsted suitings.

The *woolen* system utilizes short fibers



Drawing of a medullated wool fiber. The medulla is the core of air-filled cells that occurs in coarser fibers. The surface of the layer of cuticle cells, called the epicuticle, is labeled as an independent entity because it is chemically much different from the remaining part of the fiber, including the cuticle itself. The epicuticle is "hydrophilic," tending to absorb water.



This laboratory-scale machine is used in wool research at the Texas A&M University Agricultural Research and Extension Center at San Angelo. Using the woolen system described in the text, wool is taken after scouring and separated into individual fibers by means of rollers with fine teeth, producing a "card web," which is a thin mat of wool fibers. This machine, the woolen system condenser, then splits the card web into narrow strips, approximately half an inch in width, each of which is then spun into a thread or yarn.

that have often been harshened by carbonizing, a treatment with sulfuric acid required to remove vegetable matter. (Vegetable matter in wool refers to the burrs, seeds, twigs, leaves, and grasses that adventitiously enter animal fleeces. This category of impurity would also include the fecal material that can become attached to the wool. In wet years, the amount of vegetable material present in wool can become excessive, causing discounted prices to be offered for the contaminated wool.) The web of fibers from the carding operation is split and spun directly into yarn without parallelizing the fibers. These yarns are usually coarser and more hairy than worsted yarns, perfect for sweaters and tweed jackets.

Wool fibers exhibit a characteristic waviness known as crimp, which allows woolen yarns to entrap air. The result is a fabric with desirable bulk and excellent insulating qualities.

Since clean wool fibers are composed almost entirely of the protein keratin, there is an abundance of free amino groups. The structure of wool is such that when the wool is swollen in water, these particular chemical entities become accessible sites for acid dyes. Wool fibers thus have an excellent affinity for this class of dyestuff. Since most sheep produce white fibers, wool is easily dyed to specifications.

Although wool fibers are not particularly strong, they are extremely flexible and resilient. Wool can also be permanently set by applying pressure in the presence of heat and moisture, a tremendous asset. Compared with other natural and synthetic fibers, wool has a relatively low density, which allows for the production of light-weight fabrics while still maintaining reasonable body.

Wool fibers are more absorbent of moisture than other fibers, taking up as much as 18% moisture without feeling wet to the touch. This property means more comfort for the wearer of woolen garments, since heat is evolved during absorption of water. Thus, with their natural insulating properties, woolen fabrics make warm, comfortable clothes, particularly in cold, damp climates. The reverse process, loss of moisture from wool, is an endothermic (heat-absorbing) reaction. So lightweight woolen garments are also ideal for tropical clothing. The perspiring wearer is actually cooled by the natural phenomenon of dissipation and subsequent evaporation of his own sweat via the wool fibers (which is why the British and others traditionally wore white woolens in such countries as India).

High Tech Wool

Wool, the fiber of tradition, is finding new life as scientists apply high technology to woolen garments. We are currently experiencing an increasing trend to blend wool with other fibers. The addition of small quantities of wool to either cotton or synthetic fibers provides improved aesthetics, drape, and hand or feel as well as other characteristics such as differential dyeability that cannot be obtained by using one fiber alone. Similarly, additions of relatively small quantities of cotton or synthetic fibers allow the production of stronger, wool-rich yarns with increased utility. The physical properties relating to durability and comfort are combined to obtain the best from both fiber types, while at the same time, poorer properties of the individual fibers are suppressed.

Thanks to scientific studies, the natural self-extinguishing property of wool when ignited has been improved by an inexpensive application of metal ions. As a result, we now have woolen fabrics for firemen's uniforms and aircraft seat coverings that are completely flame retardant.

Woolen garments at one time could only be dry cleaned or hand washed in warm water, which meant an extra investment of time and money. Now wool scientists have supplied the techniques for partially removing the scales and depositing synthetic polymers on the wool fiber surface. As a result, we can machine-wash and tumble-dry woolen clothing along with the rest of the wash without unfortunate results. And fine woolens need no longer exude an aura of mothballs! Wool can be made resistant to mildew, and unpalatable to carpet beetles and the infamous larvae of clothes moths by the relatively simple application of such chemicals as synthetic pyrethroids. Application of 0.02% of a compound called permethrin durably mothproofs wool and wool-blend carpets without the danger of mammalian toxicity.

From Joseph's coat of many colors, to the cloaks of medieval knights, to World War army uniforms, to modern "dress for success" suits, wool—nature's miracle fiber—produces fabrics of choice.

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For Further Reading

1. J. G. Cook. 1984. Handbook of Textile Fibres. I. Natural Fibres. 5th Edition, Merrow Publishing Co. Ltd., Shildon, England.
2. G. E. Scott. 1982. The Sheepman's Production Handbook. Sheep Industry Development Program, Inc., Denver.
3. W. Von Bergen. 1970. Wool Handbook. 3rd Edition. Interscience Publishers, New York.

The wool coat — a blend of good fashion and good sense.