

WOOL (AS. *wull*, *wul*, Goth. *wulla*, OHG. *wolla*, Ger. *Wolle*, wool; connected with Lat. *villus*, *vellus*, OChurch Slav. *vlŭna*, Lith. *vilna*, Skt. *ŭrnā*, wool, from *var*, to cover). The soft hairy covering of sheep and several allied animals; next to cotton the most extensively used of all fibres. Its history dates back to the earliest times of which we have any record, and as civilization has progressed its uses and applications have steadily increased.

Wool Production and Consumption. The chief wool-producing countries of the world are: Argentina, Uruguay, and other South American countries; Australia and New Zealand; the United States; Russia, Great Britain and Ireland, France, Spain, South Africa, and India. The world's clip for 1915 was estimated by the National Association of Wool Manufacturers at 2,872,000,000 pounds. The consumption of wool in the United States has always been relatively large. Prior to the beginning of the factory era it did not average more than three pounds per capita of population annually, and in the middle of the last century it amounted to four pounds, but as wealth increased and the uses of wool enlarged, the consumption increased to about eight

pounds per capita in 1900. In 1915 the wool clip of the United States was estimated at 290,192,000 pounds, the product of about 50,000,000 sheep. About two-thirds of the wool used by American mills is supplied by domestic flocks. The imported wools largely used for blankets and carpets are mostly of lower quality. The principal wool-producing States are Montana, Wyoming, New Mexico, Idaho, Oregon, Ohio, Utah, California, Texas, Colorado, and Michigan, in the order named.

Sheep raising has preceded civilization in nearly all parts of the world. Before agriculture was practiced to any extent, it was almost universal. With the progress of civilization, the use of wool for making cloth led to the improvement of the fleece by selection and breeding. The Romans greatly increased the fineness of the fleece, and after the Roman conquest of the Iberian Peninsula Roman sheep were introduced into Spain, where they so greatly improved the native flocks that even during Roman supremacy Spanish wool led in the world's markets, a prestige held for many centuries. Through judicious crossing of the fine-wooled Merino with high-grade long-wooled breeds, the highest type of wool fibre has been developed, combining suppleness, fineness, and other desirable qualities with lustre and length of staple. It is suitable for combing as well as carding.

Wool may be considered a product of cultivation, or domestication, as no wild animals are known which resemble the wool-bearing sheep; and few natural products have been more modified and diversified by man to meet his various needs. This is very strikingly shown by a comparison of the coarse heavy covering of the argali or musmon (the supposed progenitors of the sheep), with the fine wool of the Merino or the long, lustrous fleece of the Leicester. These animals in the natural state were covered with coarse hair or fur, among which close to the skin is a softer hair or wool. Under the influence of good care and feed, and protection from the inclemencies of the weather, the longer coarse hair largely disappeared, and only the softer, shorter hair or wool remained, a phenomenon said to be observed when the argali is brought under domestication.

Characteristics and Properties. Wool is a living appendage of the skin, produced by increased epidermal cells. The difference between wool and hair is one of degree rather than of kind, because all wool-bearing animals have the tendency when neglected to produce hair rather than wool, and because numerous intermediate structural stages exist between the two extremes. While wool is commonly characterized by its fine, soft, curly nature, the true distinction between it and hair lies in its covering of pointed scales or plates, attached to the filament at their bases and overlapping much like fish scales. This structure, which is readily seen with a microscope, is perceptible to the touch by its harsh, rough feeling when the fibre is drawn through the fingers from the tip to the root. The number of these scales bears a fairly direct relation to fineness of the fibre. The curliness of wool is due to a spiral structure of the filaments, and although all wool is not curly or wavy, curliness is one of its recognized and important characteristics. There also appears to be a relation between fineness and curliness. Owing to the relation which these three characteristics bear to each other, curliness, or the number of waves to

the inch, which can be seen with the naked eye, is one of the factors noted in judging wool. The waviness and scaliness are utilized in making felt (q.v.) and also in thread making. A pound of the finest wool will yield nearly 100 miles of thread. In spinning, the filaments interlock by their scales, and the curl of the fibre prevents the threads untwisting and helps to hold them together. These valuable qualities vary greatly in different wools, some being adapted to carding for cloth, and others to combing for worsteds. It is upon minute points of difference that the value of various grades of wool chiefly depends. The lustre also differs greatly and to a certain extent is a breed characteristic, the wool of the Lincoln and the best Leicester sheep being much more lustrous than that of the shorter wools or the fine Merino fleece. The length of staple, which is made a basis of general classification, is largely a constitutional or breed characteristic, the staple being from 1 to 2 inches long in the finest Merinos, 8 inches or more in the Lincolns, and reaching 12 and even 15 inches in some combing wools, the length of staple suggesting the grouping of sheep into short-wools, middle-wools, and long-wools. The fine felting wools have a short staple, as a rule, and are used for carding or yarn purposes, while the longer, more lustrous, and less wavy ones are better suited to combing and worsteds.

Another valuable characteristic of wool is its elasticity, which gives it a softness to the touch which is retained in the manufactured goods. Closely related to this is the strength of fibre; a dead or inferior wool will break instead of stretching when strained. Delicate machines have been constructed for testing the strength and elasticity of fibre, for both practical and scientific purposes. Bowman found that wool fibre is fully one-fourth stronger than cotton, the strength being proportional to the diameter. Great variation, however, exists in the strength of fibres from different wools of the same class of sheep.

All wool in its natural state contains fatty or greasy matter called yolk or suint, secreted by the skin and covering the individual hairs. This serves to lubricate the fibres and prevent their matting together, and also protects the fleece from injury. It differs in quantity and exact character with various breeds and is believed to render the wool soft and pliable. The fats and the potash salts which the yolk contains form a sort of natural soap. In manufacturing wool, the yolk, which is partly soluble in water, must be removed so as to increase the felting tendency and the ability of the wool to take dye. White is the most common color of cleaned sheep wool and is generally preferred for manufacturing; but the black, fawn, cream, and gray shades produced by various breeds are utilized in their natural colors for certain kinds of clothing. Wool is soluble in a hot solution of caustic soda, while cotton is not. This fact is taken advantage of in testing woolen goods for adulteration with cotton, as when a sample of the goods is boiled with the reagent any cotton present will remain undissolved.

Variation in Properties. The wool from different parts of the same animal differs greatly in length of fibre, fineness, and structure. As a rule, the best is obtained from the shoulders and sides. That from the fore part is irregular and likely to be filled with burrs, while the loin wool is shorter and coarser, that on the hind

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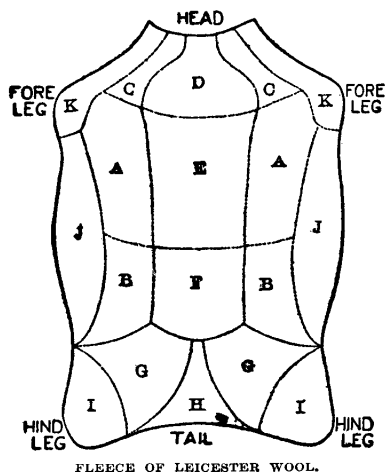
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the fibres split down from the top, interlace and mat so as to appear even on the surface, which is divided into broad masses called tops. These cannot be parted without tearing. Hemp, or kemp, consists of a mixture of short, coarse white hairs and wool fibres, occurring chiefly on the parts where the wool is lightest and shortest, but may occur all through the fleece if the sheep has a tendency to produce hemp. Since the hairs do not take dye and cannot be sorted out, they lessen the value of the fleece fully one-half for the manufacture of fine grades of goods. In cloudy wool the fibres adhere throughout their length, but not so much as to be felty. This injures the wool for combing, causing waste, but is not so objectionable in carding wools.

Wool Sorting. The differences in the quality of wool, and especially that from different parts of the fleece, render sorting a necessity. In shearing, the fleece from each sheep sticks together as a mat, and is tied up separately. In sorting, the different parts of the fleece representing separate qualities are torn off by hand. An idea of the location of the various qualities of wool is given by the accompanying diagram of a Leicester lamb's fleece, taken from Bowman's *Structure of the Wool Fibre*. The same relative positions hold good in all kinds of fleeces.



FLEECE OF LEICESTER WOOL.

The finest and most even growth of wool is found at A, on the shoulders. In some fleeces this quality extends farther up the back (E) and towards the tail (B and F) than in others, and the quality of the wool at B is not very much inferior, although rather shorter and coarser. These two qualities would be graded in the woolen trade as picklock and prime or choice, while the wool from the portion indicated by C is frequently finer but shorter than A or B and apt to contain more irregular or colored hairs. When free from these defects C is graded as super in quality. The portions D and E shade into those on each side of them, and as they form the top of the neck and shoulder, the fibre is not as deep or close as at A or C. The portion over the loin (F) resembles B, into which it shades, and for many purposes, especially for spinning down, A, B, E, and F are frequently used together as one quality. Back of F, on the flanks, the wool becomes long and coarse, the best being found in the portions marked G. The wool at H and I is the coarsest part of the fleece, growing in large locks with long coarse

hairs. It is often termed breach wool and can only be used for very coarse yarns spinning low numbers. Beyond the extremities of I there is often a still lower quality called tail or cow-tail, which is coarse and hairy, and can only be used for the very lowest numbers. The differences in quality of fibre from the same fleece are so great that a large number of sortings can be made, depending upon the character of the fleece and the purposes for which the wool is to be used. The names applied to the different qualities of wool vary in different localities, and even among different manufacturers, and this lack of uniform nomenclature is a source of no little confusion.

ESTIMATE OF PRODUCTION OF WOOL IN THE UNITED STATES FOR 1915

(United States Department of Agriculture)

Weight given in thousands of pounds	
Wyoming	29,040
Montana	28,682
New Mexico	18,620
Oregon	15,600
Idaho	15,288
Ohio	14,350
Utah	13,320
California	11,590
Texas	9,280
Michigan	8,073
Colorado	7,500
Missouri	7,035
Arizona	5,985
Nevada	5,890
Iowa	5,400
Indiana	4,920
Pennsylvania	4,030
Illinois	3,975
Wisconsin	3,960
Washington	3,818
Kentucky	3,552
South Dakota	3,500
New York	3,478
West Virginia	3,405
Other States	58,488
Total	288,777

Other Wools. Although the typical wool is produced by sheep, and it is from that animal that much the larger part of the wool supply is obtained, there are several other animals which produce so-called wool for industrial purposes. Among these are several species of goats whose hair can be greatly improved by breeding and management, furnishing a long, fine, silky material from which beautiful textile fabrics are made. No cultivation, however, has yet prevented the growth of the outer hair on goats, as has been done in the case of sheep, or changed the undergrowth of fine hair into true wool. The alpaca, closely related to or a variety of the llama of South America, yields a fibre known as alpaca (q.v.). The Angora goat (see GOAT), which yields mohair (q.v.), marks a distinct step towards true wool. The scales are less numerous than in the alpaca, but are more decided and exhibit a more definite edge. The fibres are very fine and wavy, lustrous, pure transparent white, and often 12 inches long, in some cases 18 or 20 inches. The diameter varies from $\frac{1}{320}$ to $\frac{1}{1500}$ of an inch. The annual product of mohair in the United States had reached nearly 4,000,000 pounds in 1910. Closely allied to mohair is the fine cashmere wool of India, which is the product of the Cashmere goat, common in the Himalayan mountains about Tibet. The hair is even longer than that of the Angora goat, but is not as curly. The surface of the fibres is not as brilliant as mohair, and the scales are more numerous but less distinct. Only the finest parts of the fleece are used, the yield from a single goat being

rarely more than 3 or 4 ounces. Cashmere wool is said to be the most costly of all the wools. The fine soft hair of the camel approximates true wool in its structure, and should be mentioned in this connection.

Consult: Bowman, *Structure of the Wool Fibre and its Relation to the Use of Wool for Technical Purposes* (London, 1908); Coffey, *Growing and Marketing Wool* (Ill. Expt. Station Circ. 161); Dodge, *Sheep and Wool: A Review of the Progress of American Sheep Husbandry*, United States Department of Agriculture, Report No. 66 (1900); Report of Bureau of Animal Industry, 1889-90; Marshall, *The Woolgrower and the Wool Trade* (U. S. Dept. of Agriculture, Bull. 206); Rushworth, *The Sheep* (Buffalo, 1899); Ford, *Wool and Manufacture of Wool* (1894); Wool Manufacture, Census Bulletin 236; Stewart, *Domestic Sheep: Its Culture and General Management* (Chicago, 1898). See articles SHEEP; SHODDY, and bibliography thereunder. See also WOOL AND WORSTED MANUFACTURES.