Wool and Woolen Manufactures (wool is O. Eng. weal; Ger. weide; Goth. wêla; cf. Lat. lana, Gr. λίνος, Lith. vilna, O. Bulg. вълна): strictly, the covering or fleece of the sheep, and the processes by which it is converted into textile and other fabrics. The term wool, however, has been extended to include the hair of the angora, cashmere, and other goats, the hairy fleece of the alpaca, vicuna, and other species of the llama, the soft down from the belly of the camel, several kinds of fur which are spun and woven, and even cow's hair, which is made up into a cheap quality of woolen goods. Wool proper may be distinguished from all these varieties of hair, as well as from all vegetable fibers, by the corrugated character of its fibers and by its property of felting, which is due to the epithelial scales which overlap each other along the course of its fibers, and which, under certain conditions, from their corrugation, interlock with
- each other and form a felted fabric. (See Felt.) The average number of these epithelial scales or serrations per linear inch varies greatly in different breeds of wool. The larger numbers improve the elasticity and the feltling property in line proportion. East India Angora wool has 1,000 scales per inch; common domestic, 1,400; Leicester, 1,400; merino, 2,000; Saxony, 2,200. The average size of the fiber varies, and almost inversely to the above proportion. East India measures the length of an inch; common domestic, 3½; merino, 4½; Saxony, 5½. Hair possesses very little of this feltling property, but by long beating and rubbing develops it to some extent. The primitive sheep was covered with long hair, and rudiments of the present fleece being an undergrowth or down. This hair was brood out, and the wool was left. If sheep are neglected now, or become very old, it will revert to this habit by growing hairs among their wool.

Sheep formed a large part of the wealth of the Oriental nations, particularly of those which were more or less nomadic in their habits; and as these were kept very largely for food, though sheared every year, it is remarkable that in the absence of any special efforts to improve the character of their wool it should have retained its good qualities to such an extent as to enable those nations with their rude processes to produce fabrics which, though delicate and exquisitely fine texture, as issued from their looms.

The first attempts to improve the breeds of sheep with special reference to the production of a finer quality of wool were made by the Romans about the second century B.C. Their Tarrentine sheep produced a long and finely stapled wool, and their fleeces were very heavy, but the color was either brown or black, and the sheep was so delicate in constitution that they were reared with difficulty, and were kept covered even in the mild climate of Italy. Columella relates in his De rustica that his uncle, Marcus Cucumella, who was a wealthy agriculturist in Spain, transported some white African rams of great size and beauty to his estate in Batna, and by continually crossing them with his Tarrentine ewes and their progeny succeeded in producing a breed of fine wool, which was of a characters peculiar to the fine wool production of the Mediterranean world and of the Middle Ages. It was renewed by Pedro IV. of Castile in the middle of the fourteenth century, and probably from Africa, and again with Barburary rams in the sixteenth century by Cardinal Ximenez. Its transportation to France and careful improvement there has led to the production of the French merino, one of the finest of the long-wool breeds. Its introduction into Germany, and modification by crossing with the best breeds of the country, have led to the Saxony wools, adapted to the making of the best broadcloths; and the French sheep of Naz, which yields a more silky wool, is of great interest, though now a distinct breed, having traces of its early merino origin. In the U.S. the Spanish merino, introduced by Delessert, Livingston, Col. Humphreys, and William Jarvis between 1801 and 1812, has exerted a wide influence, and, together with the Saxony sheep, the sheep of Naz, and the French merino, constitutes to this day the largest proportion of those flocks which are bred mainly for their wool. The Australian and Cape Colony wools are also largely indebted to the merino sheep for their good qualities. The greatly increased demand for mutton has led to the breeding of sheep which have larger food-producing value, and with which the wool is an incidental product. The Leicester, Cotswold, South Down, Hampshire Down, and Oxford Down among the English sheep are the best of this class, while the various Angora breeds of South America have some of the same characteristics. The large flocks of the Western States and the Pacific coast are American merinos. This all yield a portion of medium and coarse wools, while the best grade of Angora wools is valuable for the worsted manufacture, the fibers being equal in demand for carpets, friezes, and the lower grades of goods for men's wear.

Wool is divided primarily into pulled and clipped or flaxen wools, the former being either those clipped from the living one. The clipped or flaxen wools form the greater part of the wool in market, and these are again divided into long and short staple, or combing and carding wools. The clothing wools are used mainly for broadcloths and the thicker woolen cloths; the finer combing wools for soft and thin fabrics for women's wear; the medium for worsted goods, delaines, alpacas, mohairs, etc.; and the coarser for carpets, blankets, and coarse goods generally. The quantity of wool grown has increased very rapidly during the nineteenth century, especially in Europe, America, Australia, and South Africa. The increased production in Europe and America has been largely due to improved breeds of breeding and feeding the sheep, which caused them to mature earlier and to yield larger and more uniform fleeces. The introduction of the merino sheep has been an important factor in the improvement of the production of hot-chest or winter lambs. The increase in the consumption of wool in Great Britain has been enormous, and the production has increased. In 1801 the wool exported of the United Kingdom amounted to $2,000,000, the imports of unmanufactured wool to $8,000,000 more. In 1888 the production was about 12,000,000 ib., and the imports in round numbers 20,000,000. In 1877 the production was 26,000,000 ib., of which 13,000,000 was re-exported. In 1888 the production was 25,000,000 ib., and the imports 90,000,000, of which 27,000,000 was re-exported. In 1892 the production was 13,000,000 ib., and the imports 75,000,000, of which 33,000,000 was re-exported. Large quantities of shoddy, wool extract, and mungo were also consumed. The wool production of France has increased almost as rapidly as that of Great Britain, though mainly in the finer descriptions of wool; but it is now decreasing. France imports also considerable quantities of fine wools from other countries. The Austrian colony of New South Wales alone about the second century B.C. has produced nearly 55,000,000 ib. in 1875, 67,758,778 lb. in 1885, and 172,435,885 lb. for the year ending June 30, 1893. Import consists of the merino wools of Australia, the Leicester, and other combing wools high luster for worsted goods, from America and Great Britain, and the coarse long-stapled wools from Asia, Russia, and South America for carpets, etc. In 1870 the wool produced in the U.S. was estimated at 12,000,000 ib.; 1886, 264,000,000 ib.; 1890, 394,482,876 lb. of wool. Australasia produces the best wool in the world for fine combing purposes. In the U.S. the demands for wool for home manufactures have immensely increased, the wool produced by the Department of Agriculture, was 1,000 lb.; 1850, 241 lb.; 1860, 27 lb.; 1870, 35 lb.; 1880, 48 lb.; 1891, 55 lb. The scoured wool produced by the wool of 1890 was rated at 350,326,705 lb. The Department of Agriculture estimated the growth for 1891 at 283,000,000 lb., the imports at 129,303,648 lb.; total consumption after deducting exports, 413,733,083 lb. The percentage of imports was 67% per cent., and in 1890 it was 72% per cent. The percentage has varied from 21% per cent. in 1840 to 44% per cent. in 1872, the highest point ever reached. It dropped to 15.5% per cent. in 1879, the lowest point. It was 29% per cent. in 1864. The consumption of wool in 1889 in the U.S. was 4-9 lb. in 1840. It increased steadily, and was 4-9 lb. in 1890, 9-7 lb. in 1880. The world's supply was 550,000,000 lb. in 1890 and 2,450,000,000 lb. in 1890. The latter quantity was distributed as follows:

United Kingdom........... 147,475,000 lb.
Continent of Europe........ 629,567,000 lb.
North America............ 218,100,000 lb.
Australasia............ 550,000,000 lb.
Southern Africa........... 124,901,923 lb.
River Plate country........ 270,735,500 lb.
Other countries........... 204,900,000 lb.

The principal European markets for wool are at London and Antwerp. At London periodical auction sales of British, Colonial, and Australian wools are held regularly attended by the principal wool manufacturing countries. At Antwerp the bulk of the wool from the important River Plate country is disposed of. Woolen Manufactures.—The manufacture of wool into fabrics is the oldest industry of mankind. The earliest known cloth is of bichrome color, and the earliest known patterns to be found on such cloth are of the kind now known as the primitive man, or rather the primitive woman, discovered that the coarse wool of the sheep, the first of domesticated animals, could be spun into long threads, woven into cloth, and then, by rubbing and beating pulsed by the roots fresh or dried or full or filled it furnished a satisfactory substitute for the pelts of the sheeps, which had till then been the clothing of man. From these rude garments the transition to shawls, to turban, to shawls, and mantles, and, as shown on ancient Egyptian monuments, was gradual, and must have required long periods of development. The production of dyed garments, of shawls, and...
of carpets, often of elaborate patterns and requiring pro-
tected labor, was attempted at a very early period, and
the manufacture of tent and curtain cloths, of tapestry
hangings embroi
dered with needlework, and of those vest-
ments of lamb's wool and the rich imperial robes of Ty
rian purple came somewhat later. Some of the Persian,
Greeks, and Romans, cloaks, robes, and shawls must have been
very beautiful; but in the ages which followed the down-
fall of the Western Roman empire the art of manufacturing
them, like most of the fine arts, was nearly lost; the says
and dyes of the Middle Ages were made from cotton and
harsh wools. The rough fibres, made of still coarser wool
in Friesland, were still more objectionable, and the
manufacture, such as it was, existed mainly in Friesland,
in Lower Saxony, in England, and in France. After the four
teenth or fourteenth century silks, satins, and velvets be-
came the favorite and distinguishing clothing of the wealthy.
Until after the period of the Reformation the manufacture
of woolen goods was almost entirely domestic; the large
spinning-wheel and the loom had indeed taken the place of
the distaff; and the hand-loom, gradually improved, of the
rule contrivances of the Oriental weavers. Among the
thousands engaged in this domestic manufacture, some pos-
sessed greater manual skill and higher ingenuity than others,
and consequently their cloths were more in demand; and
the skill and skillfulness of their looms and spinning-wheels in
single building gave them some advantages. The dyeing
and fulling of the cloths was a separate business, and for
this a water-power was required, and so fulling-mills sprung
up every where there were considerable quantities of
wool to be dealt with. The use of the teazel for combing out a nap on the
fulled cloths dates from an unknown antiquity. There were
frauds in those days—stretching of the goods and the ex-
treme use of floods. Fleece-linens are single fibers or a
few cut from the face of one piece of cloth, then filled into the
back of another piece. If judiciously used, they im-
prove the fabric, as they not only increase the bulk, but re-

erate the whole felted product, and thus render the cloth

to the wearer. From the end of the thirteenth to the end of
the seventeenth century this domestic manufacture of worsted
weaves, bales, brocades, serges, friezes, broadcloths, and other cloths
was carried on very extensively in England, and considere-
able quantities of each were exported. The English cloths
were mainly of coarse qualities, and inferior to some of
those made on the Continent, the Spanish and Flemish fine
wools enabling them to make finer and more desirable goods.
In the eighteenth century the manufacture of both worsted
weaves and woollens began to be concentrated in Yorkshire,
Leeds, Stroud, Chippенипכm, and Huddersfield. Here
became the seats of the woolen goods manufacture; while
Bradford, Halifax, Norwich, and their vicinities absorbed the
manufacture of worsted goods and carpets. But,
though large quantities of goods were made and sold,
their quality was far from uniform, and there was no im-
provement in the processes of manufacture until the inven-
tion of the carding-machine, which first came into use in
England about 1735, and the spinning-wheel (g. c.).

The gradual introduction of these machines, and the appli-
cation of steam both as a motor and for dyeing and dressing
purposes, greatly improved the character of the English and
French cloths, but until the introduction of the power-loom
(which, though invented in 1760, did not come into general
use till about 1800) and the Jacquard loom (invented in 1811),
the woolen and worsted manufacturers had not received their

greatest impulse in Great Britain. The French manufac-
turers were moving meanwhile in a somewhat different
direction. With their fine and soft wools they directed their
attention very largely to the production of French worsted
women's wear, and with their admirable taste and delicacy
of workmanship soon achieved great success. The French
manufacturers, introduced by Fallotan at Rheims in 1801,
have never been surpassed by any all-wool product in soft-
ness, durability, and beauty. Other goods, both of wool
and worsted, pure and in combination with silk, cotton, and
linen, have been produced in England, Scotland, and France.

The broadcloths of the highest grade made in France are of
better quality than any others, except some of
the west of England goods; but the practice of adulterat-
ing wools, as well as cottons, and indeed, according to
every description of the heavier wool goods, with shoddy or the
ground and picked fibers of old woolen rags, first under-
taken in 1813 at Bally, England, but not largely used till
1846; has done much to impair the value and durability of
the lower and medium priced goods. This practice has
been carried to a greater excess in Great Britain and Bel-
gium than elsewhere. The modern shoddy is fiber of
cotton, wool, and linen, mixed with and incorporated in the semifinished
Mango is the fiber of felted rags thus picked. Both these
articles, being mixed with wool, are carded and spun; they
are never fulled or carded into the fabric like

In the U. S. the manufacture of woolen goods is almost
entirely domestic as late as 1760, and though there had been
fulling-mills from the first settlement of the colonies, there
was no woolen-factory in successful operation before 1784,
when one was established in Newport, Rhode Island. A
attempt had been made at Hartford in 1788. In 1794
the first carding-machine for wool was put in operation
in Pittsfield, Mass. Between that time and 1801 four or five
more English broadcloth of good quality was made at Pittsfield in 1804, and President Madison's inaugu-
ral suit of black broadcloth was made there in 1808.
In 1816 a woolen-mill was erected by Dr. Capron at Oskary,
Onedia Co., N. Y., and in 1817 what was then considered
a large manufacture of fine cloths was established at Mid-
deltown, Conn., which made 39 or 40 yards of broadcloth a
day. In the same year were produced what are known as
the helveloid shears, a cutting-machine with spiral blades
on a cylinder acting against a straight steel blade, and
shaping the nap of the cloth evenly and perfectly. This
machine was but first adopted in France, and not
until the world is indebted for the original and best processes for
making felted goods, carpets, hats, bodices, etc.; the knot-
ing-frame, and later the various knitting-machines, the
patent and Knowledge of these machines have been
for weaving fancy cassimere, which, with their successive
improvements, are now far superior to any other loom for
this purpose; the still more wonderful automatic Bigelow
process for making a mixed mousseline de

Crompton's improvement of Noble's wool-cromb; and the Smith moquette-loom.

The woolen-manufacturers in the U. S. have had great diffi-
culties to contend with. In addition to the increased cost of labor as compared with European countries, and the lack for many years of native wool of those qualities best adapted to their use, they have been unduly affected by high
and low tariffs, and their goods systematically depreciated by
the importers and free-traders; but they have at length
reached a position in which they can supply more than
three-fourths of the woolen and worsted goods consumed at
home, and, except in a few classes of goods, produce those
of quality equal to those of European rivals.

From 1790 to 1810 there was a large domestic manufacture
of woollen cloths proportion to the population, and the greater part of the
men and all the boys were clothed in homespun, while the
woven were for everyday use linsey-woolsey, a fabric composed of linen
and wool. In 1810 the value of this domes-
tic manufacture was at $2,700,000. By 1820
this date the domestic production fell off rapidly, and at first
the factory-made goods did not supply their place.
In 1820 the total value of woolen goods reported was
about $18,000,000; in 1830 it was
$14,505,993; in 1840, $20,096,999; in 1850, $49,536

881; in 1860, $80,734,060; in 1870, $217,988,836. In 1876,
owing to the depression of business, there was a slight fall-
ing off in production, and a still larger one in importation.
The value of the woolen goods produced in 1880 was $267,323,082;
and in 1890 it had risen to $337,765,534, of which $137,600,014 was in woolen goods proper, $72,194,645 in worsted goods, $8,938,935 in felted goods and hats, $20,796,141 in

and $55,475,542 in hosiery and knit goods. Massa-

The value of woolen manufactures in 1821 was $7,329,074; in 1831, $13,107,634; in 1840, $10,

14,914,485; in 1850, $19,148,189; in 1860, $37,064,001; in 1870, $85,356,999; in 1890, $56,986,452; in
1891, $41,069,080.

Process.—The variety of goods wholly or in part made
from wool, and of those made from other
silk and cotton, and indeed, of the Articles
of dress and ornament, which are produced in Great
British, are of such great importance that the processes to which each is subjected in its
manufacture can only be named in the most general way.
The distinction between the woolen and worsted goods be-
gins in the character of the wool used; for heavy wool
are not the finest, short-stapled, and readily felting
wool is required; for goods wholly or in part of worsted the wool must be strong in fiber, of long staple (fibers 3/4 to 5 or 6 inches in length, although shorter wool can be combed), very fine, and either naturally or by the combing process freed from the noll or short fiber, which is afterward mixed with wool, carded, and spun for felted goods. The wool, which is usually purchased in bales, is first sorted and scoured. The sorter arranges the parts of each fleece according to fineness, length of staple, and silkiness of texture; and the scouring is accomplished by throwing the wool into large tanks filled with water and an abundance of soap, keeping it at a high temperature by means of steam, and continually moving it by means of rakes or stirring- sticks driven by machinery. When thoroughly cleansed it is drawn out through rollers to squeeze out the water, and then dried by revolving fans or other means. By this scouring and washing not only is the dirt and soil removed from the fleece, but the yolk or sweat—a peculiar fatty secretion of the sheep most abundant in the merino breed—is also discharged. The British manufacturers extract these matters from the water by a chemical process, and make dregs, a low form of grease, from the process. Similar processes for extracting the fat are now being introduced into the U. S. The wool is next dyed (if it is necessary to dye it in the wool). The next process is willingness, or, in the case of Western and South American wools, burling. The object of this is to remove seeds and burs which have become entangled in the wool. The American burling-machine of various kinds do this very perfectly and, in combination with the carding-machines, picking, teasing, or moisting is the next process, and is performed by a machine which tears open the matted portions and separates the wool into small tufts. Either before or immediately after this process the wool is oiled, oleic acid or olein being now generally used for this purpose, instead of olive oil, and sometimes a mixture of olein and paraffin oil; these oils are much more readily removed from the yarn or tissage by a brief scouring with carbonate of soda and pure water than the olive oil, and there is much less danger of spontaneous combustion than from the use of the vegetable oils. The wool is now ready for the carding and slubbing processes, which, though formerly separate, are now continuous by the use of a patent feeder and condenser. Their office is to convert the wool into rolls, which are drawn out before they are spun. The spinning is the next process, and herein is another difference between woolen and worsted yarns, the yarns for woolen cloths being but slightly twisted, so as to leave them more free for felting, but those for the warp twisted more than those for the weft, as they have to bear more strain; while the worsted yarns are hard-spun and made into a much stronger thread. The slight twisting and comparative lack of strength in woolen yarn renders it more difficult to weave it on a power-loom than the worsted, cotton, silk, or linen yarns. The yarn, when spun, is reeled, and, if to be made into cloth, warped, beamed, sized, and otherwise prepared for weaving. The weaving is generally done on an ordinary power-loom for broadcloths, flannels, cassimores, satinets, blankets, etc.; on a Crompton chain-loom for fancy cassimores, yarns of different colors being introduced; or on the Earnshaw needle-loom, where the goods are made with two faces or different colors are used. Broadcloths, and indeed most woolen goods, are next scourd to remove the oil, and then, if thought necessary, dyed again, and tentered or stretched upon hooks to dry. Burling, or picking off irregular threads, hairs, and dirt, succeeds this, and then, for the cloths, come the fulling process and the teasing or raising the nap, which is sheared evenly by the helicoidal shears. It is next steamed or scalded to prevent its spotting unevenly from the rain, and pressed between polished iron plates in a powerful hydraulic press, or, as is more common now, in a rotary or calendar press. The flannels, blankets, etc., do not go through these last processes. The knit goods are made from the yarn on knitting-machines, and finished by hand. Delaines have usually cotton warp, and are woven on cotton looms, and printed, like calicoes, from rollers. Merinos, Tibetans, empress and Henrietta cloths, alpacas, with many other kinds of dress goods, are made from worsted yarns. Carpets are made from coarse wool, and do not go through so many preliminary processes before spinning; they are woven on the Bigelow carpet-looms, or some modification of them. The worsted goods are combed on a combing-machine with teeth heated by indirect application of steam, to make the fibers straight and parallel, and the noll or shorter fiber is combed out. The other processes before the spinning are much the same as already described. But the spinning of worsted and woolen yarns is entirely different. Woolen is drawn finer by the draft of the mule carriage after the roving passes through rollers. Worsted is drawn between rollers as a cotton thread. The front pair of rollers runs faster than the back pair, and thus the size is reduced. Then the thread is twisted by the revolutions of the spindle. The yarns are hard-twisted, and for some purposes, as for alpacas, musairs, and lustered goods, the lustered wools and the hair or wool or the alpacas and vicuña and of the angora goat are used. The weaving and dyeing of these goods are watched with great care. The cow's hair, camel's hair, and calf's hair goods are of cheaper grades, and in quality belong rather to the woolen than the worsted trade. Most of them contain a considerable proportion of the lower grades of wool, woolen waste, and shoddy.