By NINA HYDE

Photographs by
CARY WOLINSKY
STOCK, BOSTON

STRIPPED HALF BARE BY A SHEARER'S DEFT HAND, A MERINO SHEEP SHOWS A SEASON'S GROWTH OF WOOL. FOR 12,000 YEARS THIS FIBER HAS FIGURED ON THE LOOM OF CIVILIZATION AS AN INTEGRAL PART OF HUMAN LIFE.

Fabric of History
WOOL

IT WAS EARLY EVENING, prayer time, and as I removed my snow-dusted boots just inside the mosque, I could hear men chanting in unison and see their huge sheepskin coats hanging from pegs on pillars nearby.

I had come to Gubden, a remote village in the foothills of the Soviet Caucasus, to see what old carpets might still exist in the mosque, forerunners in design and color to those being produced in Daghestan today. The best carpets in the mosque were kept in the women's quarters upstairs—it was safer there, a less trafficked area, the old guardian of the mosque explained as I followed him up the stairs. He was wearing a tall, curly lamb's wool hat.

I walked gingerly in my wool-stockinged feet on huge old carpets as my eyes got accustomed to the dim light. Many carpets were faded and incomplete; some were riddled with large moth holes.

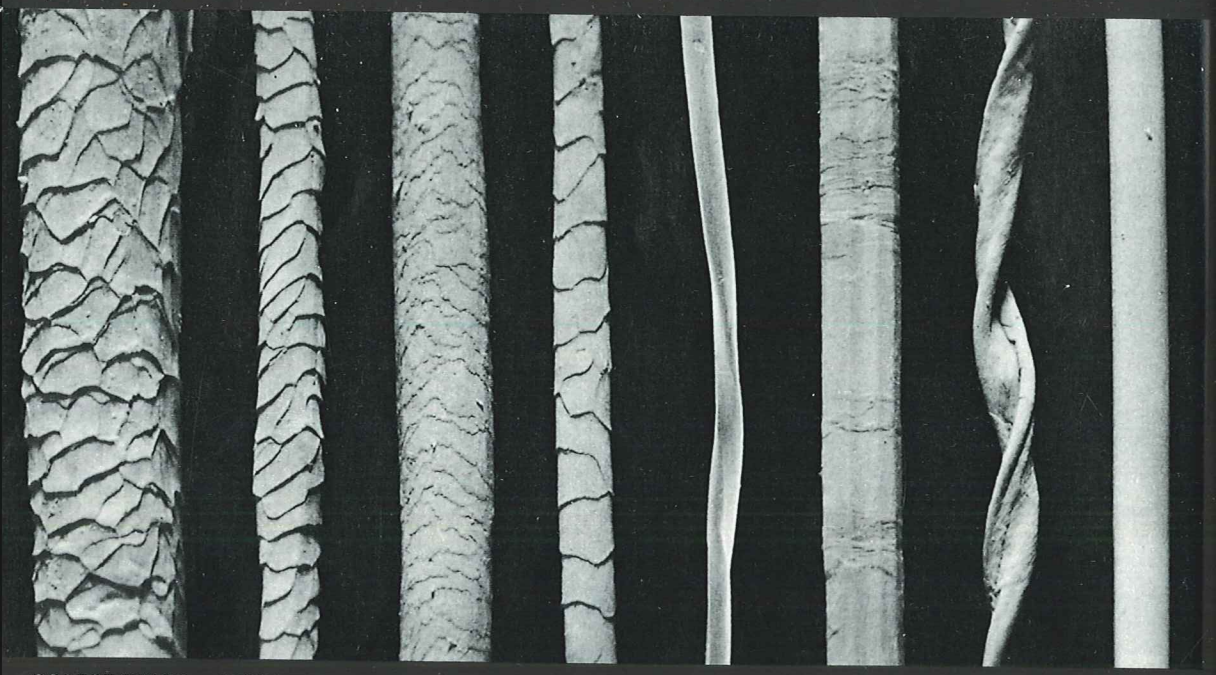
The long carpet at the center of the floor was the remarkable one. The odd and strikingly large eight-pointed star design on this locally woven, smooth-surfaced, pileless carpet had been seen before only on velvety-tufted pile carpets. Scholars had been puzzled about the origin of this Lesghi star pattern, found in pile carpets throughout the Caucasus, and here was evidence that it belongs to a pileless carpet tradition that goes back many centuries. No one knows its age for sure, but as old as these carpets are, they are modern compared with the historical scope of wool.

For 12,000 years, since man realized that with sheep he could roam and prosper on the windswept mountains and plains of southwest Asia, wool has been a civilizing force. Man almost certainly discovered the food value of sheep before wool, but when he began to fashion garments to protect his body from hot or freezing temperatures, he learned that sheep could be worth more alive than dead.

A symbiotic relationship developed—man protected the sheep from predators, sheep provided man with food and clothing. Man, whose body is least suited of all the animals to live in inhospitable climates, has made use of the natural material ever since.

Prehistoric sheep grew dark hairy coats that caught on branches or simply fell off their bodies in heavy clumps every spring. This wool could be plucked by hand, as is that of the wild Soay sheep, which now live in a feral state on uninhabited St. Kilda Island off the west coast

HER LIFE INTERWOVEN with wool, 48-year-old Gur Jan has raised eight children in this felt yurt near Urumqi in western China's Xinjiang Province. The weather-resistant, collapsible yurt has long been used by nomads from Turkey to Mongolia. Part of a semi-nomadic Kazakh tribe, she and her husband rely upon their 200 sheep for food, shelter, clothing, and income.



COARSE WOOL FINE WOOL ALPACA CASHMERE SILK LINEN COTTON POLYESTER

THE SECRET OF WOOL lies in the structure of its fibers, which absorb moisture, insulate against heat and cold, resist flame, and maintain their resilience.

Unlike cotton, linen, silk, or polyester, wool fibers are covered with tiny scales, making them look like pinecones in these scanning electron micrographs (above). When one fiber's scales rub against those of others, they pull the fibers together in irreversible tangles. When compacted under heat and moisture, the wool shrinks into felt.

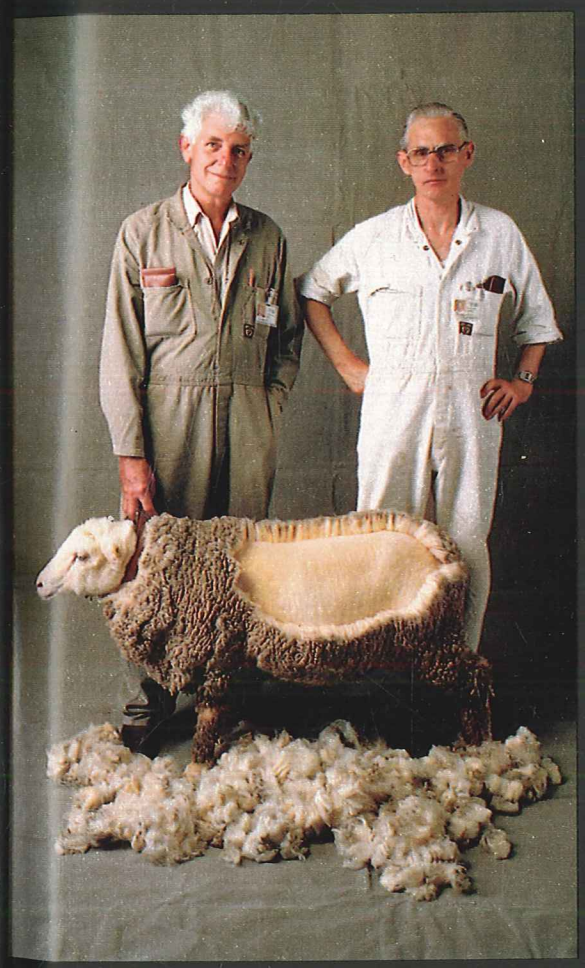
Although its scaly surface tends to repel liquids, the wool fiber's core is highly absorbent, taking in as much as 30 percent of its weight in moisture. Synthetics, by contrast, hold as little as 2 percent. By drawing perspiration away from the body, wool clothing prevents the skin from feeling clammy during summer and helps to hold in heat during winter.

Wool fibers are made of keratin, an animal protein also found in hair, nails, feathers, and horns. The larvae of clothes moths and carpet beetles feed on this protein, leaving holes in one's favorite sweaters or rugs. Cocoons of the casemaking clothes moth (above right) are difficult to spot because they often include wool fibers in their construction.

MICROGRAPHS BY LEO BARISH, ALBANY INTERNATIONAL RESEARCH COMPANY

Contained in wool grease in its unrefined form, lanolin (left) is collected during the cleaning of raw wool. Secreted by the sheep's sebaceous glands, lanolin is used in many cosmetics because it is easily absorbed by the skin.

Researchers John Bennett and Don Tunks (right) are part of an Australian team developing a way to fleece sheep without clippers. Weeks earlier this animal was injected with a biological compound that weakened each wool fiber at its base, without causing the fleece to fall out. Tufts of wool can now be pulled off by hand, leaving a protective layer of new growth behind. Such a method could greatly trim labor costs.



of Scotland, and the sheep of the Shetland Islands. Men bred sheep to produce smaller horns and longer tails, and long white wool in place of the archetypal shorter hairy outercoat and short wool undercoat. Until sheep shears came into use in the Iron Age, bronze combs or hand plucking sufficed.

Wool's unique properties make it particularly suitable for both carpets and clothing. Wool fibers have minute overlapping scales or plates, all pointing in one direction, like tiles on a roof (opposite). These interlock into felt under pressure, heat, and moisture. In one inch of wool fiber there may be 2,000 overlapping shingles, whose sharp scales can irritate sensitive skin.

Air trapped between fibers gives wool its insulating quality; wool provides great warmth for little weight. Wool feels warm since fewer fibers touch the skin compared with other fabrics, so less heat is conducted away from the skin. Smooth cotton sheets feel cold; fleecy blankets feel warm. The trapped air also keeps things cold. Near Kashi in western China I visited an underground cave used for storing ice. The heavy wooden door was insulated with thick felt. The ice is transported to customers on a cart lined with felt. Bedouin wear wool clothing as insulation in the desert for the same reason.

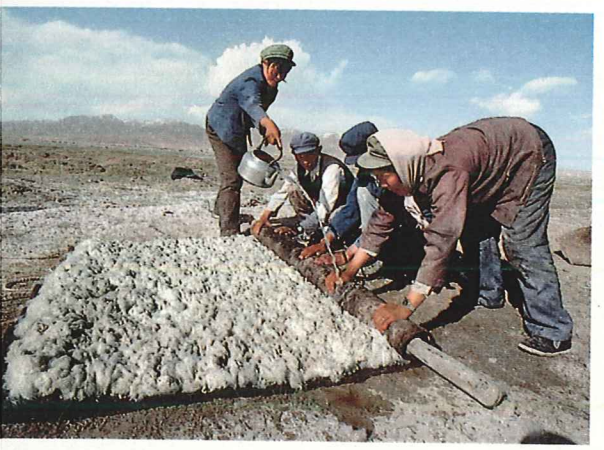
THE SURFACE OF WOOL is water resistant; its interior is highly absorbent. In fact wool is the most hydrophilic of all natural fibers, absorbing as much as 30 percent of its weight without feeling wet to the touch. (Cotton absorbs 8 percent, synthetics usually less than 5 percent.)

Porous and permeable, wool absorbs perspiration and releases it slowly through evaporation so that one feels less chilled in winter; in summer the evaporation keeps one comfortably cooled. In biblical times wool was used to collect water; a fleece was left out overnight in the desert, and the next morning the dew was wrung from it. ("And it was so: for he rose up early on the morrow, and thrust the fleece together, and wringed the dew out of the fleece, a bowl full of water." —Judges 6:38)

Wool can feel warm even when wet, something Scottish shepherds in the Highlands, who had little else to wear, appreciated when they rinsed out their plaids in the river at the start of the day. The water swells the wool fibers, making the fabric bulkier, decreasing

OLDEST CARPET in the world, this woolen pile rug (left) from the fifth century B.C. was discovered inside the frozen tomb of a nomadic tribal chief at Pazyryk in southern Siberia. Wide-ranging horsemen, his tribe maintained contacts with distant cultures. The carpet's design comes from Persia, yet it was found among bronze and silk artifacts from beyond the Great Wall of China. Also from the tomb, a felt wall hanging (below) depicts an elegant rider with non-Asian features approaching a goddess. A felt saddle cover (above), trimmed with leather, fur, hair, and gold, shows an eagle-griffin attacking a mountain goat.

ALL PHOTOGRAPHED AT THE HERMITAGE, LENINGRAD



HOW TO MAKE FELT: A Mongolian family in the Qinghai Province of China turns wool into a building material. First they place a layer of fluffed wool on dampened felt and wet it (far left). Next they roll the whole package around a pole and wrap it in a fresh yak skin (middle). Then the bundle is dragged bouncing behind a horse (top) for hours until the wool fibers are tightly compacted. This finished felt (left) will be used to line the inside of the family's yurt.

air permeability, and lowering the wind-chill effect. Maine lobstermen wear wool-knit mittens for the same reason.

As wool absorbs moisture from the air, the fibers liberate heat, explains Dr. Fred Fortess, director of apparel research at the Philadelphia College of Textiles and Science. This is a characteristic of wool that scientists have been trying to improve in synthetic fibers. A single gram of wool gives off 27 calories of heat when it goes from dry to wet.

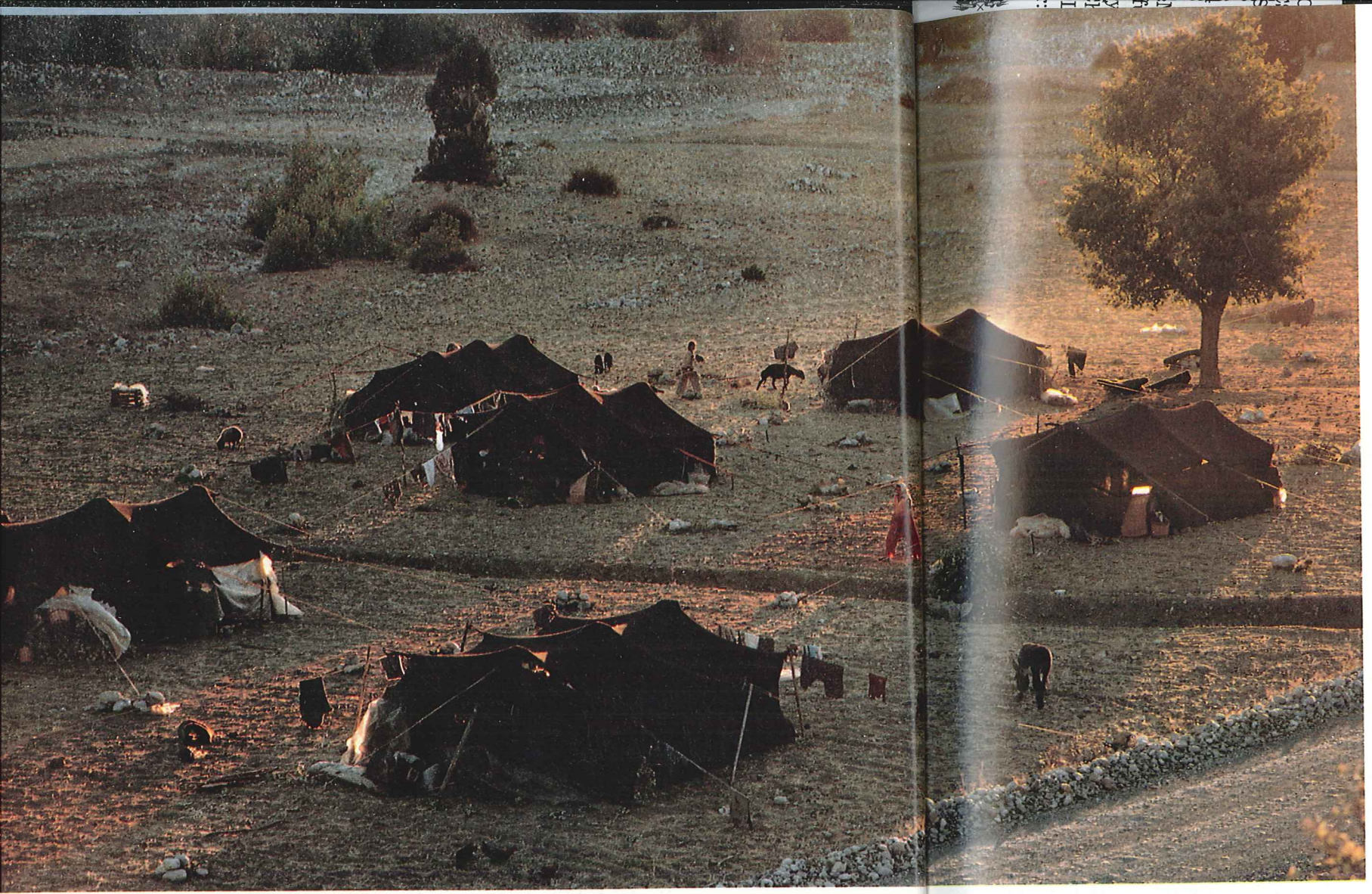
The presence of water, plus the protein keratin, makes wool naturally flame resistant, requiring a higher temperature to ignite than other natural fibers. When aflame, it burns slowly, smoldering and charring but giving off little heat. A wool blanket is an effective way of smothering a flame.

Wool has good elastic recovery, giving it a springiness that makes clothes wrinkle resistant when dry. This resilience is why 150 yards of wool yarn are used in an official baseball, and why wool felt covers piano hammers. Premature infants and long-term hospital patients are comfortably cushioned on wool pile or sheepskins.

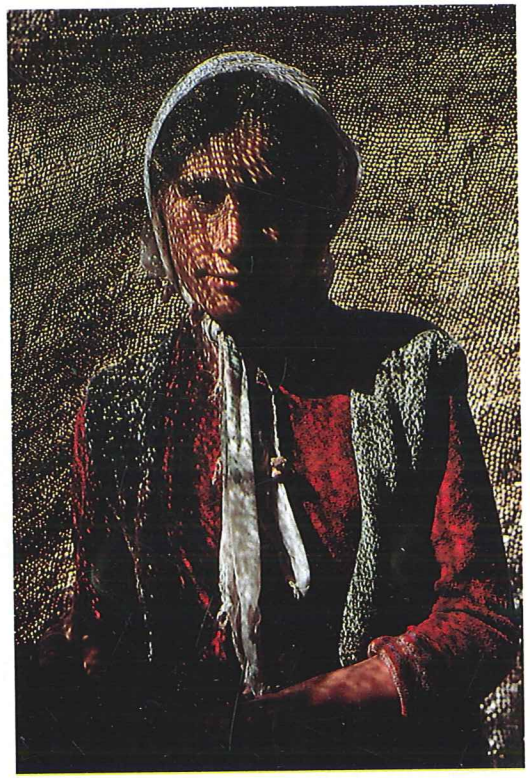
Wool can be bent 20,000 times without breaking (silk breaks after 1,800 bends, rayon after 75). Because wool is highly crimped, it absorbs odors and noise in heavy machinery and stereo speakers.

Felting compacts wool, making it less permeable, warmer, sturdier, more water resistant, and, therefore, practical for winter boots for Moscow police, tips for pens, and wheels for polishing. Unintentional felting can ruin sweaters washed and agitated in too warm water or wrung out afterward.

St. Clement, patron saint of hatters, is said to have stumbled onto felt when he put loose



WAY STATION for wanderers, a tent camp is staked in Turkey's central Taurus Mountains as shepherds of the Karakoyunlu tribe bring down flocks from high summer pasture. Besides wool, their animals give them hair for saddle bags, bridles, and ropes. The open weave of their goat-hair tents allows sunlight to shine in and smoke to pass out, but the loose fibers repel the rain.



wool in his sandals for comfort on a long journey; the moisture, movement, and warmth transformed the wool into felt. The first woolens were more likely to have been felted into a densely matted wool than woven. One can imagine the continuous rediscovery of felt—felt as it appeared on the body of a sheep as it molted, felt from the piece of loose wool used for kneeling on the ground or for sitting on a camel's back.

Nomads of central and western Asia used felt for clothing and tents. Greeks felt-lined their helmets, and Roman soldiers wore breastplates of felt. Pliny the Elder, whose *Natural History* was considered a scientific sourcebook in the Middle Ages, said that felt treated with vinegar would resist iron and fire.

I know that felt keeps you dry, even in a heavy rain. I walked in a downpour with Turkish shepherd Umer Acar as he tended his sheep. He was wearing the *kepenek,* the customary hooded felt mantle that seemed to sip in the water. My high-tech parka, tapped by the raindrops, felt clammy, and my pants were wet to the knees, but Acar was dry from head to foot. "Without a kepenek I couldn't last half a day in the rain," he said. "With one, I can stay out until I need to go home."

Nomads appreciated the transportable value of felt tents as they moved between two seasonal grazing areas, commonly going to the mountains in the summer. Today tractors and trucks make travel easier, but this transhumant style of living in western China goes on much as before with families on horses and household items strapped to yaks.

As early as the eighth century B.C., nomads traveled in felt-covered wagons and later developed felt yurts as they roamed from China to central Europe. Yurts are circular dwellings with domed roofs capable of withstanding strong winds. Thick felt is lashed onto a diagonal wood lattice supporting a willow frame. Nomadic life has disappeared in many regions, curbed by governments wanting to keep closer tabs on these traditionally independent groups. Yet even today yurts dot the landscape from Turkey to eastern Mongolia—a quarter of the way around the world—in a band a thousand miles wide.

Once you have lived in one, a yurt is hard to give up. In Kirghiz in Soviet Central Asia, many former nomads move back to their felt yurts during the summer, sometimes just a few miles or even a few yards from their houses. And in a cemetery in Frunze, where the Kazakh steppe meets the foothills of the Tian Shan range, metal structures over the graves are like skeletons of yurts. Visitors had knotted white wool onto these structures for luck and to keep away evil spirits.

On the other side of the Tian Shan, near Kashi in China, Gur Jan, a Kazakh woman, told me she couldn't imagine life without a yurt. "I know that the yurt is best for me. My head is clearer, and I never snore in the yurt," she said, as she offered me a murky cup of salty ewe-milk tea.

IN CHINA, felt is sometimes made today as it was centuries ago. Ta Yi, a shepherd who lives with his family in a white felt yurt in Yin Den at the edge of Caka Lake in Qinghai Province, offered to show me, but shearing was still a few weeks off, and they had no wool. No matter. On the road I spotted

TRIAL BY FIRE singes a suit designed in Melbourne, Australia, for race-car drivers. Dougal Pleasance of the Australian Wool Corporation demonstrates his confidence in the chemically treated wool fabric. The suit passed the test, protecting his arm for 20 seconds. Wool is naturally flame resistant; the suit's outer layer smolders, forming a heavy ash that protects the inner layer. A bumper sticker spotted in New Zealand offers another reason to wear wool.

a young boy with a pile of wool. We bargained; I bought the 15 jin (16.5 pounds) of wool for 52 yuan (about $14), a price that seemed high at the time, and brought it back to Ta Yi. "It is the fleece of a dead sheep," he told me, "but it has enough oil in it and will do fine."

These people use old felt to make a new felt, and the next afternoon with Ma Ma, his wife, his son, son-in-law, and a friend, Ta Yi pulled the wool apart and lined up fistfuls of it on the dampened felt, the darker wool for the bottom layer, the whitest wool on top. The family sang and chatted for almost two hours while they systematically put down the wool and fluffed it with a two-pronged wire wand. They kept adding heavy doses of water from a marsh nearby.

Then, rolling the old felt and new wool together in a skin from a freshly killed yak, they placed a pole through the center to act as an axle. A young man rode on horseback in circles, the felt in the yak skin dragging behind him (pages 560-61). The felt was checked after an hour, more water added, the package tied up and bounced around some more. Two hours later the process was still unfinished; it would be continued in the morning.

The felting process of shrinking and pounding cloth to give it a smooth, tight finish is called fulling, the root of the common English name Fuller. It's an old process, illustrated in a wall painting at Pompeii and used today in factories producing tennis-ball covers in England and loden cloth in Austria.

Fulling was a hand process in Scotland when families hand-spun and hand-carded wool from sheep on their crofts to produce Harris tweeds. Called "waulking" (the wool was originally compressed by foot), it's now done mostly for show. In Leverburgh, on the Isle of Harris, I joined a group of women waulking a tweed, thumping it on a table and throwing it to one another.

In the old way, the tweed was first soaked in stale human urine collected in a big wooden tub in an old shed. The ammonia in the urine acted as a cleaning agent. But at Mary MacKenzie's house on Harris each woman used a bar of soap while she sang to keep the rhythm of the fulling going.

BEARING A SORROWFUL MESSAGE to loved ones, the designs of Irish fishermen's sweaters were said to identify the bodies of drowning victims, since each pattern belonged to a different family or village. The origins of the patterns themselves are lost in Celtic history. Relatively waterproof as well as warm, the close-knit woolen jerseys protected fishermen from the elements while allowing them freedom of movement.

SPINNING WAS INVENTED when someone realized that twisting fibers makes a yarn, a phenomenon likely to have been noticed first when sheep turned wool into strands by rubbing against something. Linen, the fiber of flax, existed before wool yarn, but it is likely that wool was spun first since it took no elaborate preparation; it could virtually be spun off the sheep. Today shepherds along the road near Qinghai Lake in central China, and women seated on the curb in Leh in Ladakh, twist armfuls of loose wool onto a wooden spindle using a technique known since the Stone Age.

There are more than 300 references to sheep and lambs, more than to any other animal, in the Old Testament, one of the earliest written records of sheep. Isaiah says the Lord "shall feed his flock like a shepherd: he shall gather the lambs with his arm, and carry them in his bosom, and shall gently lead those that are with young." Jacob, a master breeder, gave son Joseph his famous coat, probably of parti-colored wool. Jesus' cloak, for which soldiers drew lots, must have been wool. Last year Pope John Paul II flew to the United States in a plane appropriately named *Shepherd One*.

The Old Testament forbids the mingling of wool and linen, a teaching some Jews follow today. Joseph Rosenberger of Brooklyn, New York, tests clothes for this unkosher mix called *shatnes*. I went to see him in his shatnes laboratory in the Williamsburg section of Brooklyn. A slim, white-haired man with a long, thin beard, he sat hunched over a table, wearing glasses of his own design fitted with long curved lenses that magnified five times. "My father had a clothing store in Austria," said Rosenberger as he continued to study the brown worsted suit on the table in front of him. "I was interested to learn, but there was only very amateurish study over there."

He enrolled in a textile high school in New York at night and studied on his own in the library. "I learned everything," he says proudly. "But when I went to the congregation to talk about shatnes, they didn't believe me. They thought I only wanted to pull money from their pockets."

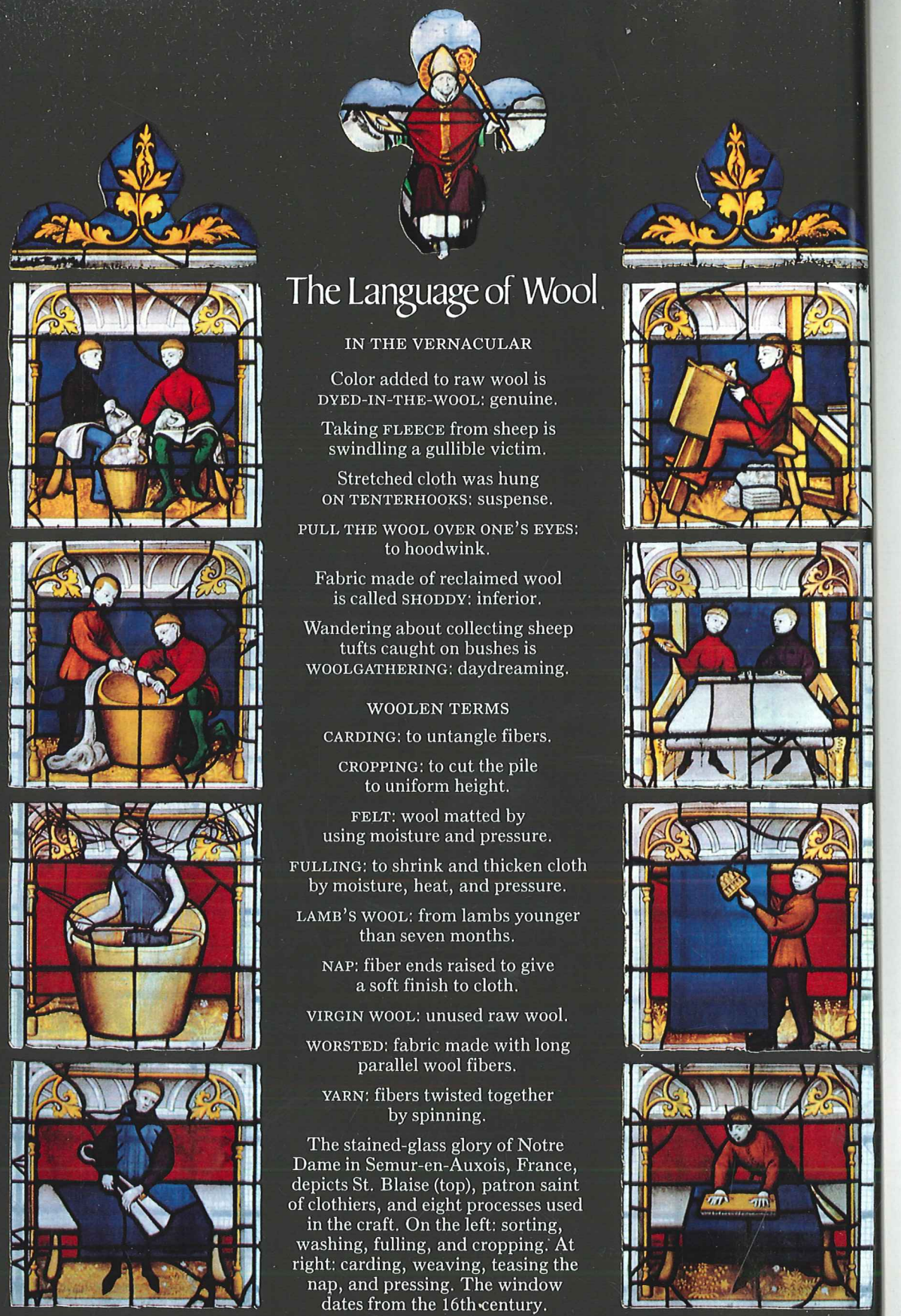
Now he tests 10,000 garments a year. Each gets a non-shatnes label if it passes his test. While I was with him, a frantic young man rushed in with a Ralph Lauren pin-striped jacket over his arm. Rosenberger checked the fibers on the back of the collar—"That's where you find most shatnes"—plus the lapel and the pocket. Sometimes he checks seven or eight places, other times 15 or 20 or 40, particularly on imports. This garment was pure. "No linen, thank God," said the customer as he paid his two dollars and raced out of the building.

EVER VIGILANT in his crusade against nonkosher fabric, Joseph Rosenberger uses magnifying glasses to examine a jacket in his Brooklyn, New York, laboratory. The Old Testament, he explains, prohibits the wearing of clothes made from shatnes, a mixture of linen and wool. To help people identify such fabric, he set up a nonprofit organization that has trained inspectors all over the world.

WOOL IS WOVEN into English idioms in intriguing ways. Even dyed-in-the-wool optimists, when fleeced by a wolf in sheep's clothing who has pulled the wool over their eyes, feel as defenseless as newly shorn sheep. A bellwether was the lead sheep in a flock, while shoddy was the term used for poor reused wool in the Civil War.

Wool is threaded through our literature with legends of Jason's quest for the Golden Fleece, Odysseus escaping the Cyclops' cave by hanging onto the woolen underbelly of a giant ram, and Penelope nightly unraveling her weaving to delay suitors until Odysseus's return. Salome's veils may have been wool, and so, probably, was the carpet that Cleopatra used to smuggle herself in to see Caesar.

No one knows for sure. Wool, like other natural fibers, is biodegradable and returns in time to its constituent elements. Leather, wood, and textiles, unlike metal and stone, are rarely part of archaeological finds. So the surviving examples of wool fabrics of the Pazyryk collection, buried in the Altay Mountains 400 years before Christ, are truly astonishing: Mummified bodies of the tribal chief and his



The Language of Wool

IN THE VERNACULAR

Color added to raw wool is DYED-IN-THE-WOOL: genuine.

Taking FLEECE from sheep is swindling a gullible victim.

Stretched cloth was hung ON TENTERHOOKS: suspense.

PULL THE WOOL OVER ONE'S EYES: to hoodwink.

Fabric made of reclaimed wool is called SHODDY: inferior.

Wandering about collecting sheep tufts caught on bushes is WOOLGATHERING: daydreaming.

WOOLEN TERMS

CARDING: to untangle fibers.

CROPPING: to cut the pile to uniform height.

FELT: wool matted by using moisture and pressure.

FULLING: to shrink and thicken cloth by moisture, heat, and pressure.

LAMB'S WOOL: from lambs younger than seven months.

NAP: fiber ends raised to give a soft finish to cloth.

VIRGIN WOOL: unused raw wool.

WORSTED: fabric made with long parallel wool fibers.

YARN: fibers twisted together by spinning.

The stained-glass glory of Notre Dame in Semur-en-Auxois, France, depicts St. Blaise (top), patron saint of clothiers, and eight processes used in the craft. On the left: sorting, washing, fulling, and cropping. At right: carding, weaving, teasing the nap, and pressing. The window dates from the 16th century.

wife or concubine, a saddle cover of felt and leather, felt figures of swans stuffed with goat hair, a horse harness with carved wooden rams' heads, and a fleece are among the things on view—all in near-perfect condition.

The perplexing piece in the collection is a knotted carpet, a large work with lotus ornamentation in the center and concentric borders, one depicting fallow deer, another, horses and riders.

With Ludmilla Barkova, keeper of the Pazyryk materials, I examined fragments of wool, then sat around a table with Dr. Anatoly Ivanov, head of the Oriental department of the Hermitage in Leningrad, who acted as interpreter.

Barkova is convinced the carpet did not originate where it was found. "My opinion and the opinion of the department is that it was not locally made but rather Iranian," she said, with the confidence of a woman who has studied the subject for 20 years. "It is known that Iran at that time produced high-quality carpets. The ornamentation is Iranian, and the horses and spotted deer and costumes would appear more appropriate to Assyria and Iran than southern Siberia," she said. British expert Jon Thompson, however, believes that the carpet with its 1,125,000 knots could be a refined nomadic artifact.

SILVER FIRST-CENTURY A.D. ROMAN SHEPHERD TOTES A LAMB IN A SKIN BAG. PHOTOGRAPHED AT THE BRITISH MUSEUM

While carpet patterns hold clues to a cultural heritage, for the Living Buddha, Lobthang Huadan, who sits on carpets daily to pray, pattern and color make little difference. We spoke briefly in his office at the Taer Lamasery in Lushar Zhen, 15 miles from Xining in central China, one of the largest Tibetan Buddhist lamaseries outside Tibet. Sitting in a chair placed against pink Christmas-wrap papered walls, the Living Buddha with his crew cut seemed more like a junior history professor at Princeton than a mystical being.

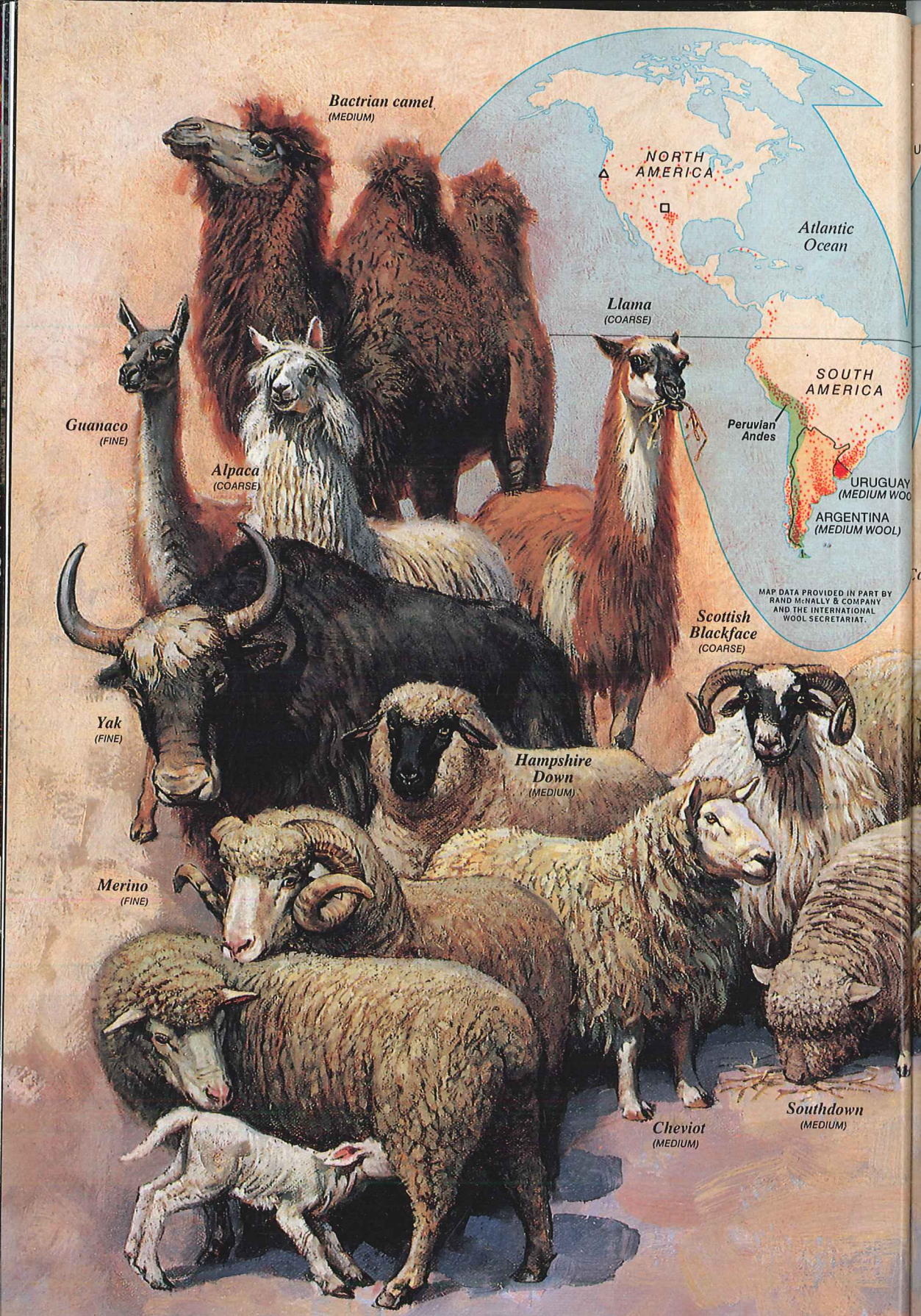
Lamas here pray in the great hall of carpets—166 pillars are wrapped in colorful carpets, and long rows of seats are covered with them. I asked the Living Buddha if the patterns or colors had any religious significance. "Not really," he said tersely. He's a practical being. "My favorites are the thickest ones. They are the most comfortable to sit on."

"THE FLOWER and strength and revenue and blood of England," wrote one 17th-century English scholar. The Romans built a factory for warm cloth in the third century A.D., and wool cloaks and blankets were early exports.

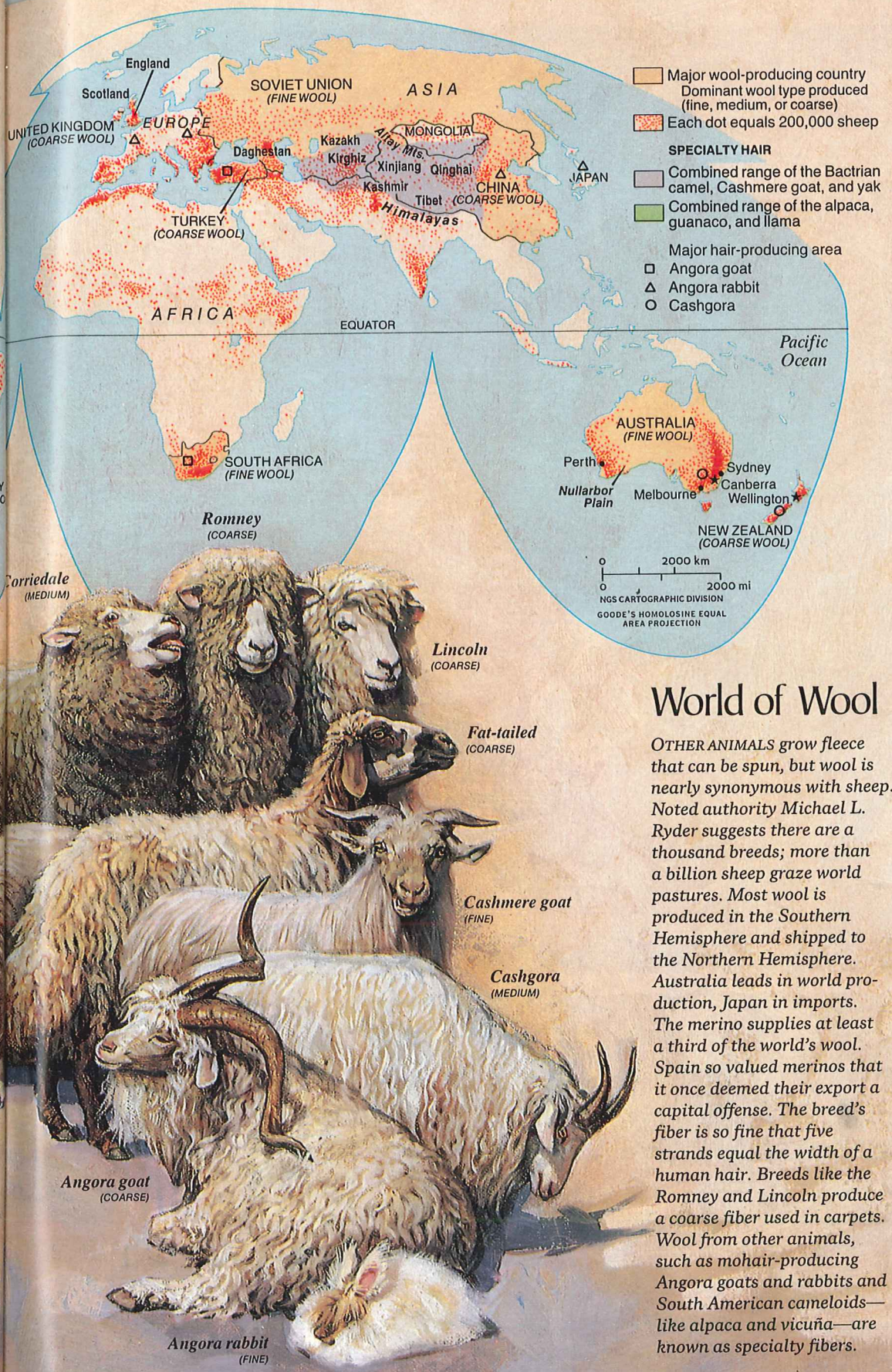
In early medieval times English sheep served their main purpose by fertilizing fields as well as by providing food. But by the middle of the 13th century the wool trade was making landowning abbeys, like those of the austere Cistercian monks, very rich. Buyers would pay as much as three times the going price to monasteries for wool of a more consistent quality. It was an entire year's wool from the Cistercian and two other monasteries, not money, that was promised as ransom for King Richard the Lionhearted when he was taken prisoner in Austria on his return from the Third Crusade in 1192. (It was never paid in full.)

Futures trading, that exhilarating carpet ride to riches or ruin, was invented by the Cistercians. In their attempt to flee worldly life, they created self-contained empires, leaving sheep raising to their lay brothers. So when offered contracts and advance payments for future sales of their wool, it suited them not to be bothered annually with such matters, and the Cistercians made contracts for sale of their wool production two, three, even ten years hence. Everything was fine until the clip showed up short or the sheep developed scab, forcing the Cistercians to buy wool at high prices to fill the orders.

Futures trading was not the only financial innovation from wool trade. In the 1400s those patrons of culture *(Continued on page 574)*



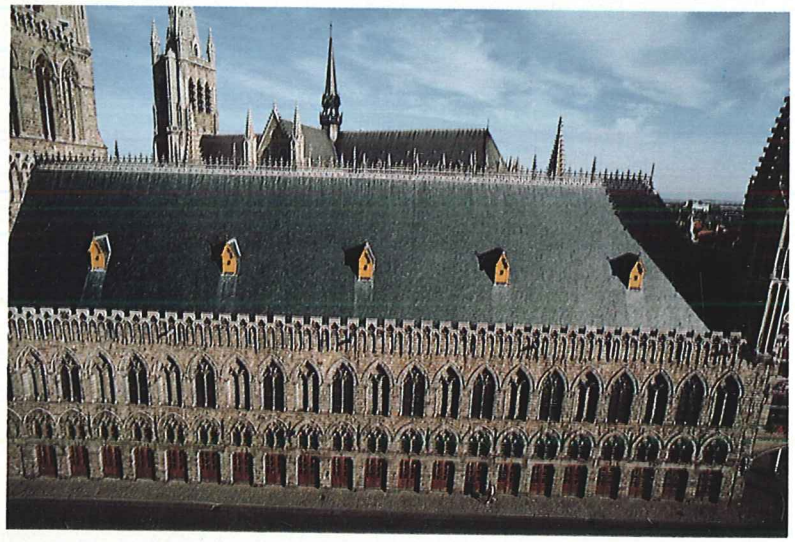
PAINTING BY JAMES M. GURNEY



World of Wool

OTHER ANIMALS grow fleece that can be spun, but wool is nearly synonymous with sheep. Noted authority Michael L. Ryder suggests there are a thousand breeds; more than a billion sheep graze world pastures. Most wool is produced in the Southern Hemisphere and shipped to the Northern Hemisphere. Australia leads in world production, Japan in imports. The merino supplies at least a third of the world's wool. Spain so valued merinos that it once deemed their export a capital offense. The breed's fiber is so fine that five strands equal the width of a human hair. Breeds like the Romney and Lincoln produce a coarse fiber used in carpets. Wool from other animals, such as mohair-producing Angora goats and rabbits and South American cameloids—like alpaca and vicuña—are known as specialty fibers.

BRADFORD INDUSTRIAL MUSEUM



CROWDED LIKE SHEEP, traders once jammed the floor of the Wool Exchange in Bradford, England—as simulated in this 1904 montage (above)—to buy and sell the commodity that brought wealth and power to England for 700 years. Made obsolete by modern communications, the exchange is no longer active. But a handful of members still gather regularly (above right), as much to socialize as to discuss business.

Wool was England's first great industry. By the late Middle Ages its export had become the nation's largest source of income. Flemish cloth merchants were England's best customers during the 13th century, when the great Cloth Hall (far left) was built at Ypres in what is now Belgium. Raw wool from England was unloaded directly from ships on the Yprelee River, while merchants displayed samples of their wares at stalls facing the street. Weavers emigrating from Flanders later helped England improve its own cloth-making industry.

Demand for English wool enriched great landowners in such areas as the Cotswolds. William Midwinter, a prominent local woolman, is depicted in a 16th-century brass memorial (left) on the floor of St. Peter and St. Paul Church at Northleach. With one foot on a sheep and the other on a woolsack, he is remembered as the town's high bailiff, as well as a prosperous merchant who sold raw wool to the French.

TO THE RHYTHM of lively songs, women on Scotland's Isle of Harris demonstrate the traditional method of "waulking" a length of tweed. Each seizes a double handful of woven wool, soaked in soapy water, and thrusts it to another, who returns it just as vigorously. This thickens the Harris tweed, famous for its strength and durability.

and captains of industry, the Medicis, built their wealth on the wool trade in Florence. They developed a banking system, establishing bills of credit at home and abroad that gave them power and money to act as patrons to artists of the Italian Renaissance. Dante, Leonardo da Vinci, and Michelangelo were among those who benefited from the patronage of the wool guild, the Arte della Lana, which supervised the building of the Duomo.

In the Middle Ages wool was the staple of England's export trade, and every European country relied on England for it. Royal finances were boosted by the taxes and fees in the wool trade, and kings and ministers got power through the granting (and withdrawing) of concessions to wool towns and the wool industry. Even children were not allowed to forget the royal connection. In the nursery rhyme "Baa, Baa, Black Sheep," the first bag, the "One for my master," probably refers to the export tax on wool.

In his zeal for wool, Edward III placed in Parliament symbolic red square sacks of wool. In the course of time they were filled with hair, probably because wool was so valuable. (In 1938 they were once again filled with wool, and today the lord chancellor sits upon a royal woolsack to address the peers of the realm.)

Flemish weavers, prompted first by the stiff restrictions on wool exports and later by religious persecution, were lured to England with promises of protection and tax exemption. Other refugee weavers from Holland and France introduced new methods that helped England's wool industry become the best in the world.

DURING this early industrial revolution, manufacture of wool moved to rural areas to escape the restriction of cities and guilds and to be near a natural supply of fuller's earth and water for fulling. A "putting out" system developed, whereby clothiers bought the wool and gave it to spinners, weavers, and fullers working at home on piece rates. At each step, credit was used, and middlemen, or woolmen, became very rich and contributed heavily to the magnificent "wool" churches like the one at Lavenham in East Anglia.

The population grew faster than jobs in 16th-century England, and the high price of wool turned farmlands into sheep pastures. As Sir Thomas More wrote in Book One of *Utopia* (1516): "Your sheep, which are usually so tame and so cheaply fed, begin now . . . to be so greedy and so wild that they devour human beings themselves and devastate and depopulate fields, houses, and towns."

By the end of the 18th century there were more than 300 British laws touching every aspect of the trade, from clipping sheep to prohibiting the export of wool. In 1571 a man could be fined for not wearing a wool cap. By 1662 mourning clothes had to be made of English wool. And in 1667 a law required everyone to be buried in wool. Shepherds were buried with a tuft of wool on their chests: It explained to their Maker why they never got to church on Sunday.

Mechanization was accepted more readily in the cotton than in the wool textile industry. Workers fought the introduction of machinery in the bloody Luddite riots. "The name comes from legendary Ned Ludd, a village idiot, who had destroyed some machinery. Luddite was an eponym for that act and workers' idiotic rebellion against modernization," says historian Terry Murphy of American University in Washington, D. C. In the 1830s child labor was curbed from 15 to 10 factory hours daily, and children were released from the physical restraints that kept them at the machines.

FOR CENTURIES the wealth of the Iberian Peninsula was based on the fine-wooled merino, one of the earliest breeds of sheep. Merinos were jealously guarded; few left Spain, and then only by the grace of the royal court. But in 1765 the Spanish king sent 92 rams and 128 ewes to Saxony. Three hundred more were imported nine years later, and by the end of the century German wool set the standard for the world. Before long, despite sizable duties, German wool was flooding England.

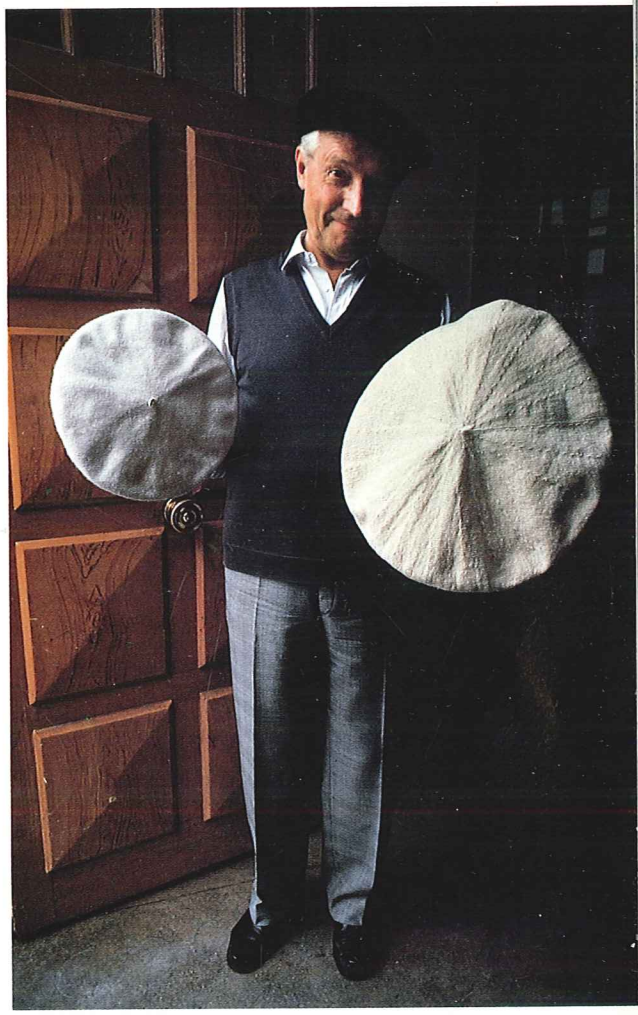
Australia's economy was built on sheep and wool. Sheep first got there from England in 1788 on a boat whose main cargo was convicts. The first sheep barely survived the passage, and most of them were eaten. They were fat-tailed, coarse-haired sheep; purebred merinos, picked up soon afterward at Cape Town, made up the founding flock.

A trade war between the Australians and Germans began. Australians concentrated on price and quantity; Saxons focused on fineness, but their sheep grew less wool and had less vigor. By 1845 even the Germans were importing Australian wool.

About the same time, big wool-consuming countries went to Australia for wool auctions. Recently I sat in on one in Sydney, watching the bids on wool bales displayed in the two-million-square-foot wool store—at 54 acres the largest wool warehouse in the world.

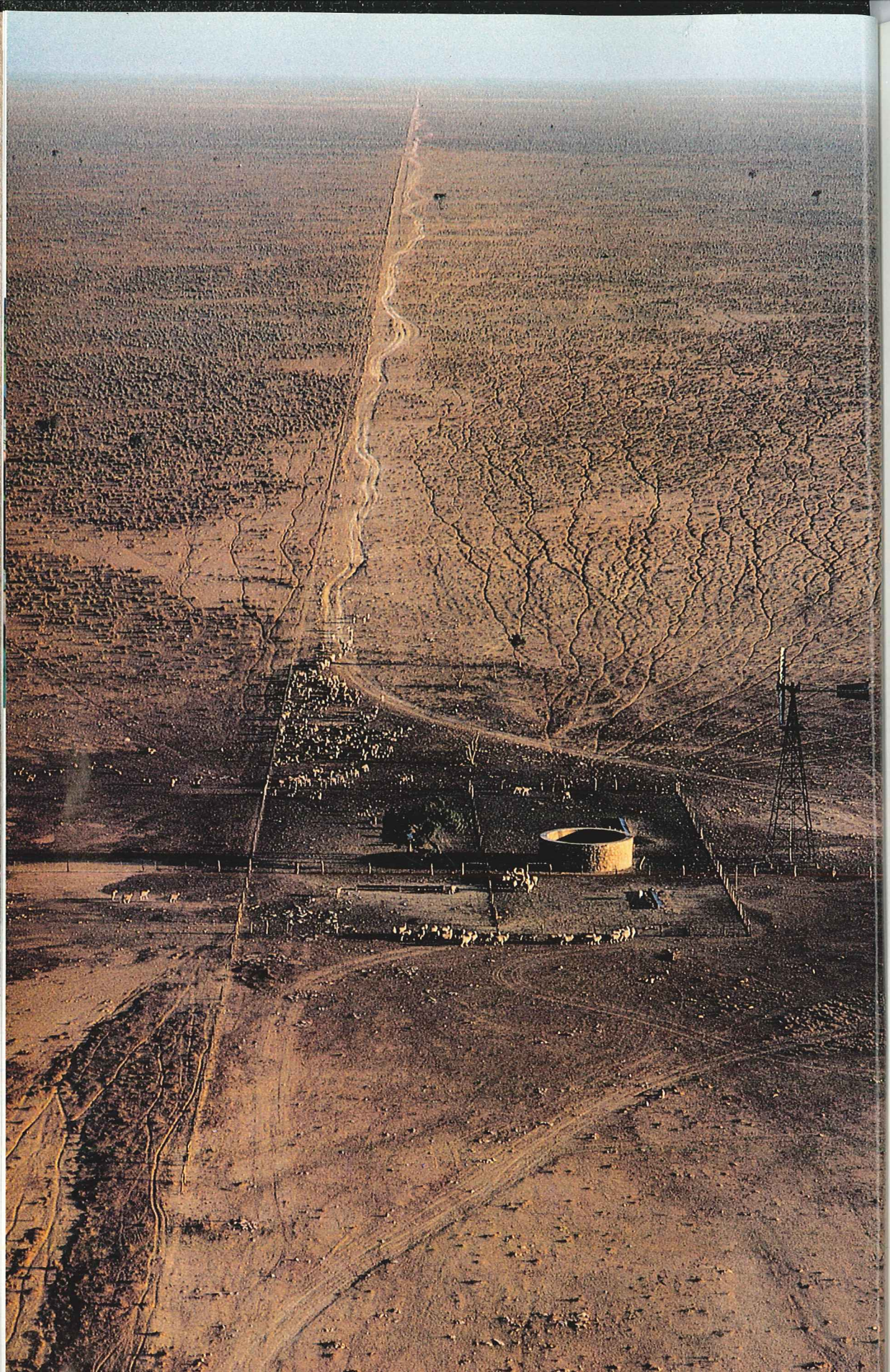
When the bid was at a floor price established by the Australian Wool Corporation, its representative bought it to save ranchers from short-term discrepancies in the market. The Australians have had in reserve more than one million bales at a time waiting for the price to rise above the floor price. But today wool is doing very well, selling in February 1988 at a record price of 32,000 Australian cents ($230 U. S.) a bale, and reserves are only 6,000 bales.

BEFORE AND AFTER: Two berets in the making demonstrate the shrinking effect of fulling. Maurice Beighau runs a beret factory in the French town of Oloron-Ste.-Marie in the Pyrenees. Like all genuine wool berets, the ones he is holding—designed for France's elite alpine troops—were first knit, then beaten while wet.



Down the road from the wool store in Sydney the Australian Wool Testing Authority is helping make this selling system obsolete. Some old-time buyers still rely on their eyes and noses, pulling apart and sniffing wool samples, judging quality from the color and crimp of the wool samples placed in long rows of cartons before the sale.

Since 1984, 98 percent of wool sold by auction in Australia has been objectively tested for



fiber diameter, vegetable-matter content, and clean-wool yield.

At a remote sheep station some 70 miles from Mount Cook in New Zealand, Russell Emmerson is challenging synthetics head-on, literally. His goal is to breed uniform superfine wool, with computerized objective measurement of the highly heritable factors of wool diameter and fleece weight. The sheep don't know it, but their computer ear tags guide their selection for breeding programs and even open paddock gates to meet suitable mates. This way Emmerson can guarantee a particular micron count instead of an average.

RATHER THAN A MOVE into the technological future, a step backward has boosted Turkey's wool trade. Villages that have a long-standing weaving tradition still weave rugs using old patterns often found in mosques. Before the European synthetic dyes reached Turkey in the 1880s, natural dyes from plants were used that mellowed in time in the light. By the turn of the century aniline dyes caught on; some were unchangeably harsh, while others faded or ran with washing. Subtle natural colors gave way to brash oranges and flashy pinks, changing the look and lowering the value of Oriental carpets.

Dr. Harald Böhmer, a science teacher from West Germany working in Turkey, who as a hobby analyzed dyes in old carpets, sold Bonn on the idea of reintroducing natural dyes to weavers, hoping to bring some prosperity to villages without disturbing village life. West Germany had cut off Turkish immigration and was interested in encouraging an industry that would employ Turks at home.

He remembers well that June day in 1981 when he and his wife, Renati, went to Süleymanköy near Ayvacık, a hilly, partly forested area in western Turkey near the Dardanelles. There recently settled nomads wove poor rugs with easy-to-use chemical dyes. "We stood near the well in the center of the village, first dyeing wool red with madder that we had brought with us, then yellow from wild chamomile we had collected," Böhmer recalls.

At first a few women came, watching cautiously. But eventually more and more came, attracted by the brightly colored, freshly dyed skeins of wool hanging from the lower branches of a nearby tree. "They had known how to make black from acorn shells, but they had forgotten that you could make colors from plants," said Böhmer. Using a tea glass as a measure, "since every house had one," Böhmer wrote out simplified but specific recipes for natural dyes.

"Two days after the first class, 20 families were weaving with natural dyes," Böhmer says modestly. In two months his project had produced 20 small rugs.

WOOL NOT ONLY HAS an impact on many economies and the way people live, but it also touches our health. Keratin, wool's complex and tough protein, is the principal matter of human nails and hair and the protein of human skin; much of what we know about skin has been learned from wool research.

It's the same protein that makes wool irresistible to moths. Larvae can spend more than half of their life cycles consuming wool. It is said that Romans had bare-breasted virgins beat the surrounding bushes to rid them of the pest. Another early treatment was cow manure and garlic. Now mothproofing can be done in the dyeing stage with chemicals that kill larvae through their digestive systems.

As I excavated through 24 layers of beautiful felts and carpets in the women's gallery of the old mosque in Khasavyurt in remote Daghestan, I saw that moths had done the same, drilling through the entire stack. I asked Levy Kelaty, whose seven acres of warehouses in London store half a million carpets from around the world, for his solution to the moth problem. Proper washing discourages moths, he said. Other than that? "I just pray."

The durability of the fiber lets wool survive the rag trade, which recycles wool clothes. I followed the rag trade to its capital, Prato, Italy, a prosperous art and textile center near Florence. Rags are sorted by color and weight, treated with chemicals to remove impurities, shredded, spun, and rewoven into cloth.

Reused wool is never as strong as new wool,

INHOSPITABLE TO MAN but well suited to merino sheep, Australia's arid Nullarbor Plain supports vast ranches, such as 4,000-square-mile Rawlinna Station. With 40 acres for each animal, these merinos survive well on sparse vegetation and salty water. Australia dominates wool production, providing a fourth of the world's supply.

SHEEP IN MAN'S CLOTHING, a flock of merinos outside Canberra, Australia, wear woven plastic coats year round. Originally intended to protect the animals from cold weather during the first six weeks after shearing, the polyethylene coats were discovered to offer other benefits: They reduced skin temperatures during hot weather; discouraged flies from laying eggs in the fleece; improved milk supplies; prevented discoloration of the fleece and made it softer; and reduced the amount of dirt, seeds, burs, and other vegetable matter that collected in the wool. Such contaminants, along with wool grease and body salts, can account for as much as half the weight of an average fleece.

Prized for their fine white wool, merinos represent the pinnacle of selective breeding. Raised in Spain during the Middle Ages, they are now kept in many parts of the world. By contrast, feral Soay sheep (left) resemble the primitive sheep of Bronze Age Europe. Found on the islands of Soay and St. Kilda off the west coast of Scotland, the Soay shed their fleece once a year, while merinos and other modern varieties have been bred never to molt and must be sheared annually.

but sometimes the two are hard to tell apart. U. S. Customs checks imports in its laboratories at major ports to assure that reused wool is properly identified.

THE MODERN SHEEP is a 24-hour-a-day fiber factory, with each fiber growing .008 inch a day. There can be 60,000 wool follicles per square inch of skin and a hundred million fibers in one fine merino fleece. One merino can produce nearly 5,500 miles of wool fiber in a year, at the rate of two-thirds of a mile an hour. The fibers of five merinos, joined end to end, could tie a bow around the world.

Pasturage affects the quality of wool a sheep produces. And when a sheep's teeth loosen with age, it can no longer chew well, so the animal loses its value as a wool producer. Dr. Adam Thomson, an Edinburgh dentist, has been working on splints to support loose teeth. Pregnancy and stress affect wool too.

It's remarkable what meager greens will support sheep. I walked with Dungar Ramuji, an 18-year-old shepherd in the Great Indian Desert outside Bikaner. I could hardly see a shred of green in the dry, cracked ground until Dungar pointed it out. He starts his day at six o'clock in the morning, walking 14 hours in the hot sun and wind in a shirt, a thick cotton shawl, and carrying his lunch, a *chapati* made by his wife. With a long stick he whacks at the dry bushes to make it easier for the animals—about 100 small, dusty sheep and 150 lean, black goats—to reach the moist roots. "Sometimes I walk 20 miles, to a farmer who lets me graze the animals while they fertilize the ground," Dungar says.

The diameter of a wool fiber is measured in microns (a micron is forty millionths of an inch) and ranges from 10 to 70 microns. But the finest "wools" don't come from sheep at all but from agile animals that climb the highest mountains—the goats of Kashmir, Tibet, and the Pamir Mountains, and the shy vicuña of the Andes.

Perhaps the finest of all is *shahtoosh,* made from the fleecy underwool from the neck of the wild ibex goat in the Aksai Chin, a militarized zone on the Chinese side of the Himalayas. Fibers are collected by peasants from bushes and smuggled across closed borders into New Delhi. There the airy fibers are sold to dealers in third-class hotel rooms, then sent to weavers in Kashmir. The fibers are so fine that they must be treated with starch made from rice so they will not break.

Says Stanley Marcus, who owns many shahtoosh scarves, "Next to shahtoosh, cashmere feels like burlap." In a recent Neiman-Marcus catalog, a large shahtoosh "ring shawl," so fine that it can be pulled through a wedding ring, was priced at $20,000.

The length of sheep's wool varies dramatically. It can be as long as 16 inches, depending on the pasturage, breed, and what part of the body the fiber is from. The first-year wool, or lamb's wool, is always the finest growth on a sheep. In Deuteronomy (18:3-4) the first fleece was given as a tribute to the priest. "The first fruit also of thy corn, of thy wine, and of thine oil, and the first of the fleece of thy sheep, shalt thou give him."

Growing fibers are lubricated by wool wax, or wool grease, whose by-product, lanolin, is used in cosmetics and pharmaceuticals. Until 1974 the grease from the effluence of local wool processing plants fueled the fire for a steam engine for the local water authority in Yorkshire.

A bale of raw wool, or grease wool, straight from the sheep, can contain as little as 50 percent wool, the rest being wool grease, burs, seeds, and other vegetable matter, body salts, and dirt.

SINCE CLASSICAL TIMES herders have jacketed their sheep to keep them as clean as possible. Pliny tells us that the best jackets for sheep were Arabian sheep wool. On a station near Canberra I was amused to see sheep in people's clothing. But it is serious business for John Hyles. Many of his 10,000 merinos wear green plastic coats made on the premises (preceding pages). It pays off. Hyles figures that the jacketed sheep yield 3.5 percent more wool and bring 50 cents more per kilo.

Shearing, estimated at 22 percent of total cost, is the single greatest expense in wool production, and because there is a concern that shearers are a declining breed, new shearing methods are being tried. Robot shearing is being tested at the University of Western Australia in Perth. Sheep, lying on their backs in a cradle, are trimmed by a state-of-the-art robot that can judge the shape and wrinkles of the animal and even respond to unpredictable bumps and breathing. Once captured and trussed belly-up, the sheep appears to relax and, in fact, seems hypnotized while the robot passes over most of its body to peel off the fleece in one piece.

Experiments with chemical shearing that began at the U. S. Department of Agriculture in Beltsville, Maryland, have developed into a biological wool-harvesting study in Sydney, Australia. In a process that would turn shearers back into pluckers, researchers are developing a biotechnical process to weaken the fleece and allow the wool to be pulled away with the ease of Velcro. A compound from glands of male mice, called epidermal growth factor (EGF), is being tested; it has proved safe for sheep and wool. EGF induces a temporary stoppage of the cellular activities of the wool follicle and, therefore, weakens each fiber. Successful trials have been conducted with several breeds.

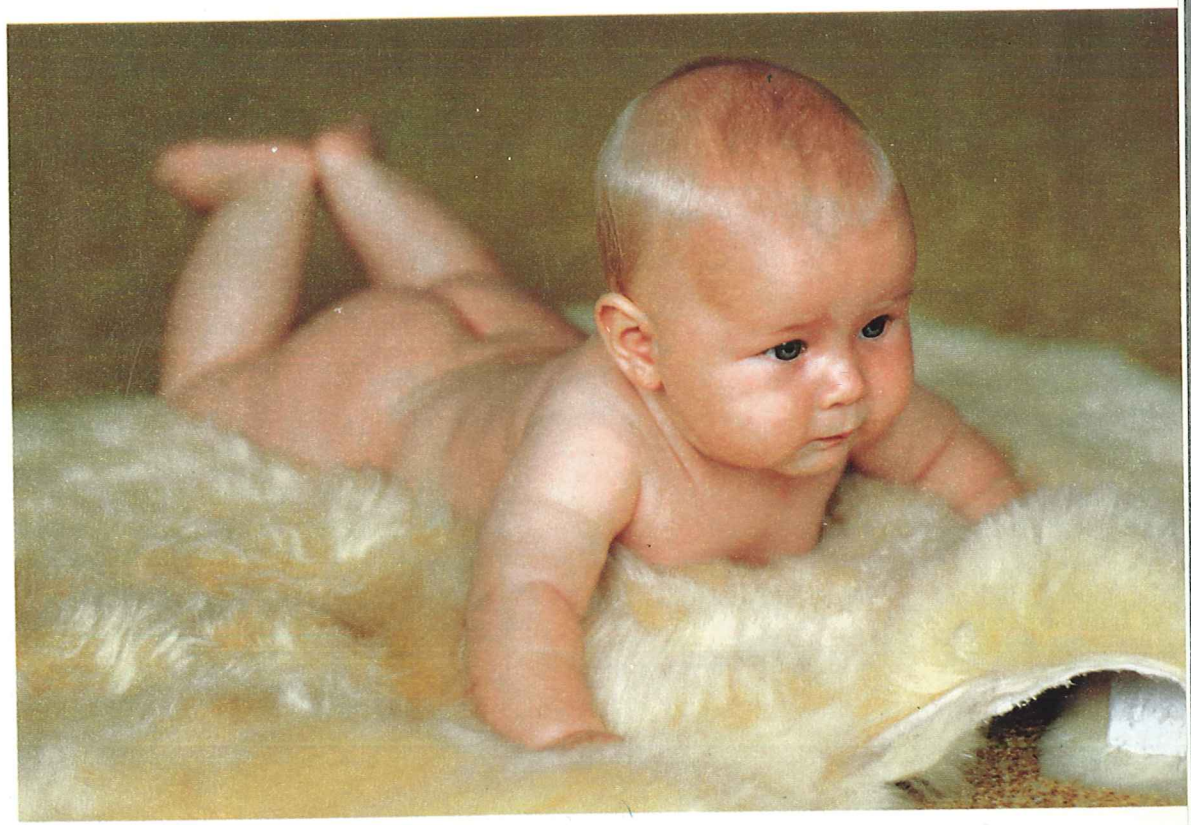
Australia's Commonwealth Scientific and Industrial Research Organization is also trying, through genetic engineering, to produce sheep with the ability to grow better wool. They want to develop genes that will enable sheep to produce sulfur-amino acid, a key nutrient in wool growth, and not have to rely on pasturage for it.

Although 3.8 billion pounds of clean wool were processed in 1985-1986, wool represents only 5 percent of all textile fibers used in the world. Australia is far and away the biggest producer, followed by the U.S.S.R., New Zealand, China, and Argentina.

The Soviet Union, because of its long cold winters, its conservative attitude toward synthetics, and the considerable amount of wool it uses in military uniforms, is the biggest consumer, using as much wool as the United States and Japan combined.

Australia's 160 million sheep produce a quarter of the world's supply of wool and 70 percent of wool used in clothing. While the country's 80,000 sheep stations have flocks averaging just 3,000 to 5,000 sheep, some stations in Australia are huge—bigger than Rhode Island or even Puerto Rico.

I went aerial mustering with Murray McQuie, who manages one of the largest, a 2.1-million-acre station on the Nullarbor



PAMPERED WITH LOVE, Kelly Randell snuggles into a sheepskin at a baby-care center in Wellington, New Zealand. Infants are thought to benefit from contact with sheepskins, which many New Zealanders put in cribs, strollers, and car seats.

Plain in southwestern Australia. Even 60,000 sheep can get lost in such space. We swept over the dry and dusty area in his Cessna 175 to look for the flock for lamb marking and shearing. When he spotted some sheep, McQuie used his radio to guide the roustabouts on motorcycles below. "Are you blokes in the area?" he shouted as he swooped down to herd a few stray sheep toward some others.

COMPARED WITH Australian wool production, North American efforts have always been small-scale. Even so, the limited wool industry in the Colonies so alarmed the British that in 1699 all wool trade except with England was punishable by stiff fines.

This and other economic restrictions helped ignite the American Revolution. Spinning and weaving became a symbol of patriotism, with classes held on the Common in Boston and near City Hall in New York. George Washington did his part by raising sheep at Mount Vernon, where nearly 400 yards of wool cloth was produced each year. Immigrant weavers and other wool-trade craftsmen were quickly given citizenship, and the industry began to build.

Those who pioneered the West took sheep with them. The Navajo, who got their first sheep from Spanish colonists, learned to weave and adopted the collapsible, vertical loom from the Pueblo. Pueblo men wove in cotton, but the Navajo women adapted this craft to wool.

"Many of the things we are famous for we stole—rugs, silversmithing, sand painting—and we always improved on them," says R. C. Gorman, a Navajo artist living in Taos, New Mexico. The Navajo soon abandoned the conservative Pueblo designs and applied Spanish tapestry-weaving techniques to blankets for themselves and for trade. When they unraveled the *bayetas* (red coarsely woven Spanish shawls) and incorporated the wool, their designs became more sophisticated.

Since the Navajo accepted sheep in reparation for their internment in the 1860s near Fort Sumner, New Mexico, wool and sheep have been at the economic and cultural center of Navajo life. Navajo rugs are virtually money in the bank and will always bring cash at Joe Tanner's trading post in Gallup.

Mrs. Barbara Jean Ornelas and her sister, Rose Ann Lee, worked on a handsome rug for two and a half years. But when Mrs. Ornelas needed money to pay her husband's college tuition, she took time out to make a small rug that she quickly sold for $800. The sisters remember being forced, as seven- or eight-year-olds, to weave on facing looms. "We would cry and weave at the same time," says Ornelas. Now she loves to weave. "Weaving is good for my mental health—I sort things out. And it's a tie to our past." Her mother always says on her birthday, "Don't give me flowers. Give me wool."

At a trading post in Gallup belonging to Joe Tanner's brother Ellis, I saw a child's dress made of two rugs sewn together. It was a ritual dress for the puberty ceremony, though few girls wear it any more, Deloria Ashley told me, because it is so itchy. Deloria invited me to her sister's puberty rite, a four-day affair culminating with the baking of a Navajo cake in a six-foot-wide shallow hole in the ground and an all-night session of singing with the medicine man in the hogan. The hogan, with its hexagonal shape and door facing east, bedding rolled up at the back, and stove in the center, reminded me of the Kazakh yurts in China.

At sunrise about 15 blankets, topped by the brown-and-white one I had brought as a gift, were neatly stacked on the ground outside the hogan, and the young girl stretched out, face down, on them. An aunt pulled her limbs so she would grow tall and slapped her mouth four times so she wouldn't talk too much. Blankets used in this ceremony are considered blessed, and the women in the family put their handbags close by, hoping the blessing would spill over into them.

To me the ritual seemed a symbolic recognition of the remarkable properties of wool. Throughout the world wool has been the fiber of civilization, a lucky resource to myriad cultures, underpinning entire national economies. And for some people, like the Navajo women, it has been a special blessing in the fabric of their history. * * *

THE CAT'S ALIVE, but the rest of Noeline Black's knitting friends are stuffed. Created by Black and other members of the Fabric Art Company in Wellington, New Zealand, they reflect the humor and ironies of domestic life. Taking yarn from her own leg, the woman at far right is unraveling herself to make the baby she has always wanted.