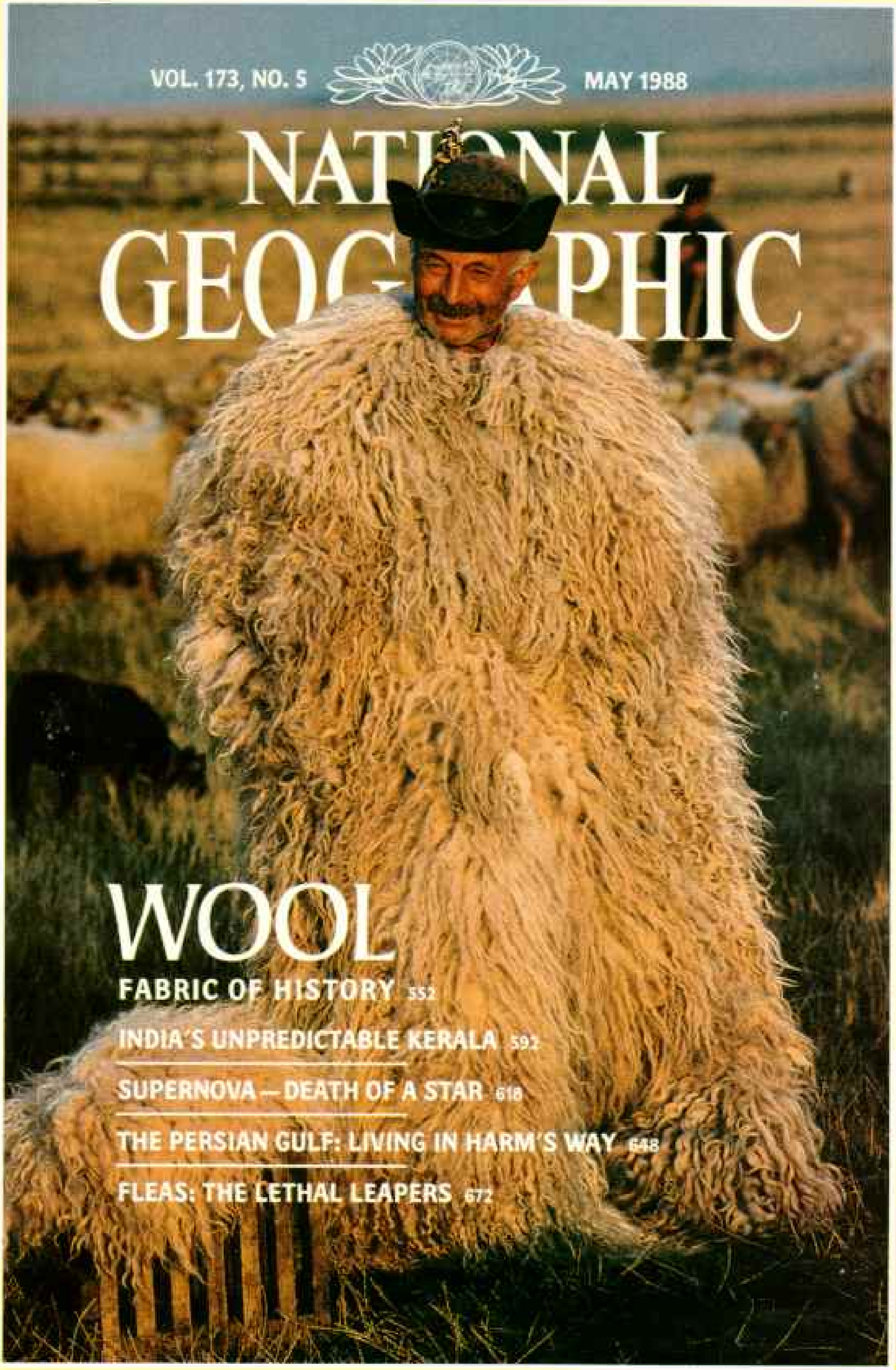
1888 · CENTENNIAL · 1988

VOL. 173, NO. 5 MAY 1988

NATIONAL GEOGRAPHIC



WOOL

OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY WASHINGTON, D.C.

1888 1988 NATIONAL GEOGRAPHIC

MAY 1988

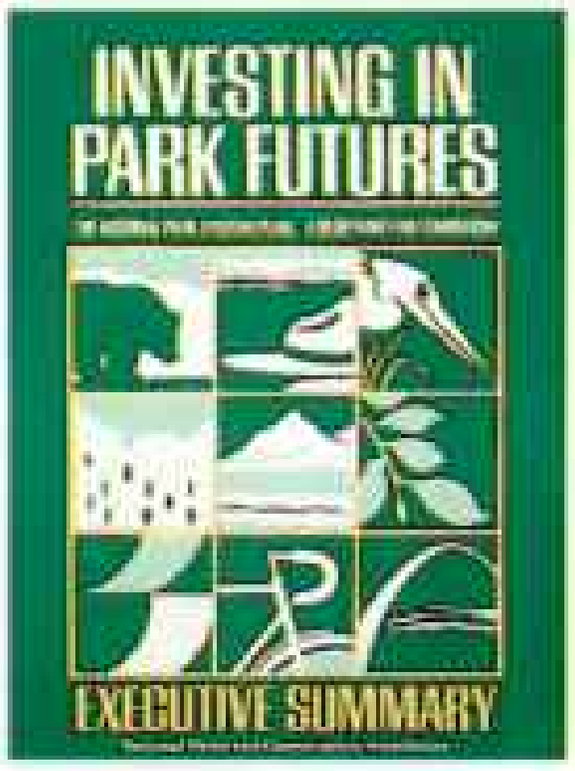
COVER: *A man in sheep's clothing, a shepherd in eastern Hungary wears a coat known as a suba. Photograph by Cary Wolinsky.*

THE NATIONAL GEOGRAPHIC MAGAZINE
IS THE JOURNAL OF
THE NATIONAL GEOGRAPHIC SOCIETY

FOUNDED 1888

Most of us want and need a bit of nature's land to call our own, to cultivate and to enjoy, whether it be a backyard flower plot, a penthouse garden, or a potted plant in a window. Nations have theirs—they're called national parks. But just as the hardiest potted plant will never bloom but will wither and die if not cared for, the same can happen to a park system.

And that's exactly what's happening to ours, according to a just-released study of the U. S. National Park System, "Investing in Park Futures." It warns that not only are our parks withering from lack of care, but in order to be responsible caretakers of our nation and sensitive to its needs in the future, 86 new areas should be added to the system as soon as possible.



This three-year study by the National Parks and Conservation Association is a bit like a letter from a friend telling you to get your act together for your own good. The association, in its 70th year, serves as a nongovernmental, citizen-run friend and critic of the National Park System.

Paul Pritchard, president of the association, told me, "We are free of political constraints. Yes, we are very critical of what's happening to our parks, but our fire is aimed not so much at the Park Service but at ourselves. We've identified a 522-million-dollar backlog of resource management needs alone, and it's getting worse. There should be a 50-million-dollar increase in budget annually just to catch up and keep up."

That's not half the cost of one MX missile. But in an election year, with candidates trying to outdo each other in supporting cost and tax cuts, few will rush to embrace the report. A grass-roots citizen demand to support our parks is what the report recommends and what is needed. Not doing so is as foolish as not fixing a leaky roof on your house. Eventually the whole house will be ruined, and the quality of life for you and your children will be diminished dramatically. And the parks are yours as much as the potted plant that you water, feed, care for, and may even talk to.

For copies of the report, write to the National Parks and Conservation Association, 1015 31st Street N.W., Washington, D. C. 20007.

Wilbur E. Garrett

EDITOR

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.

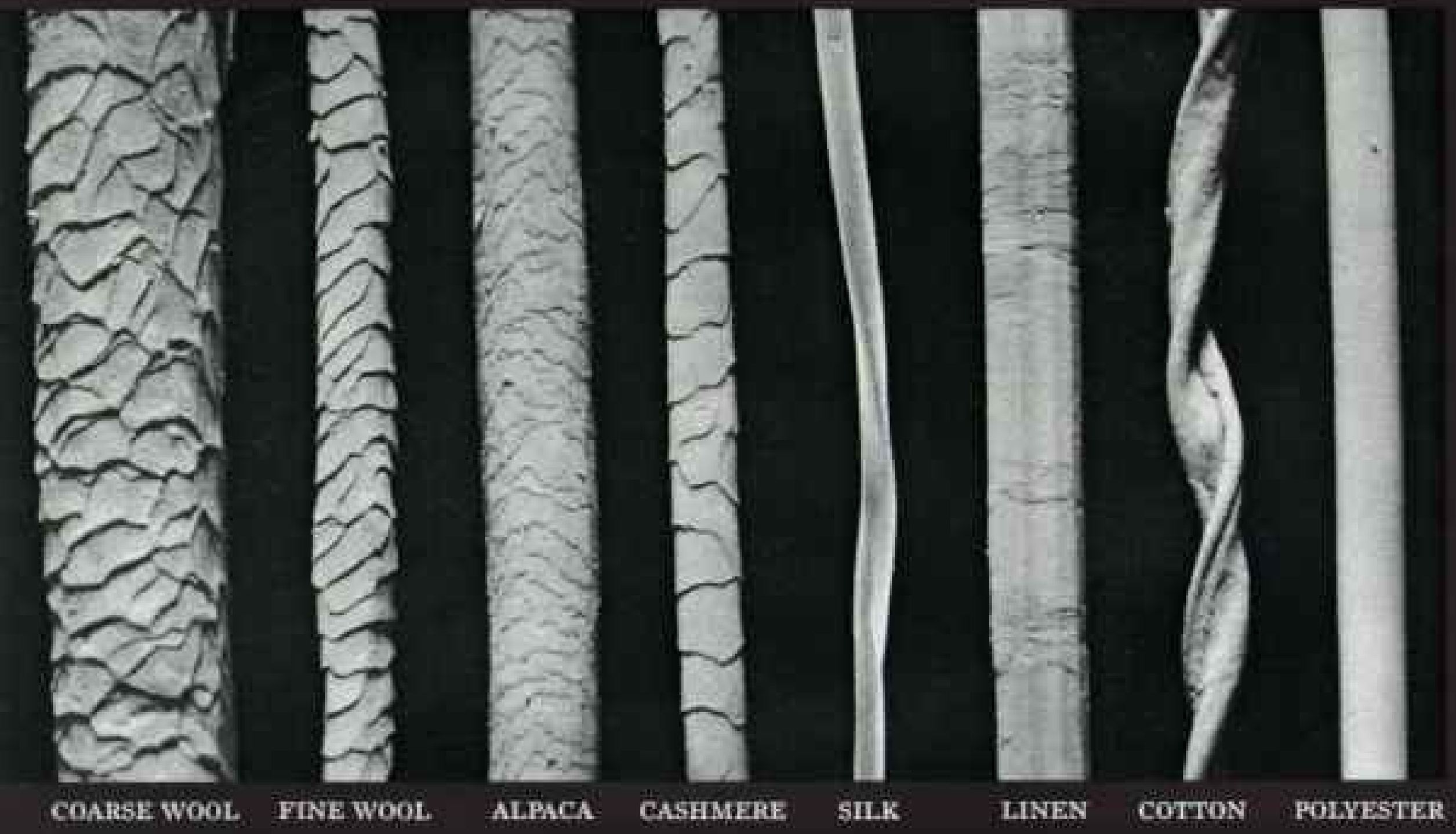
For 12,000 years, since man realized that with sheep he could roam and prosper on the windswept mountains and plains of southwest Asia, wool has been a civilizing force. Man almost certainly discovered the food value of sheep before wool, but when he began to fashion garments to protect his body from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

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.

MICROGRAPHS BY LEO BARISH, ALBANY INTERNATIONAL RESEARCH COMPANY

Wool—Fabric of History

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

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

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.

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

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.

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.

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

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.

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)*

Bactrian camel
(MEDIUM)

NORTH AMERICA

Atlantic Ocean

Llama
(COARSE)

SOUTH AMERICA

Peruvian Andes

URUGUAY (MEDIUM WOOL)

ARGENTINA (MEDIUM WOOL)

Guanaco
(FINE)

Alpaca
(COARSE)

Scottish Blackface
(COARSE)

Yak
(FINE)

Hampshire Down

Merino
(FINE)

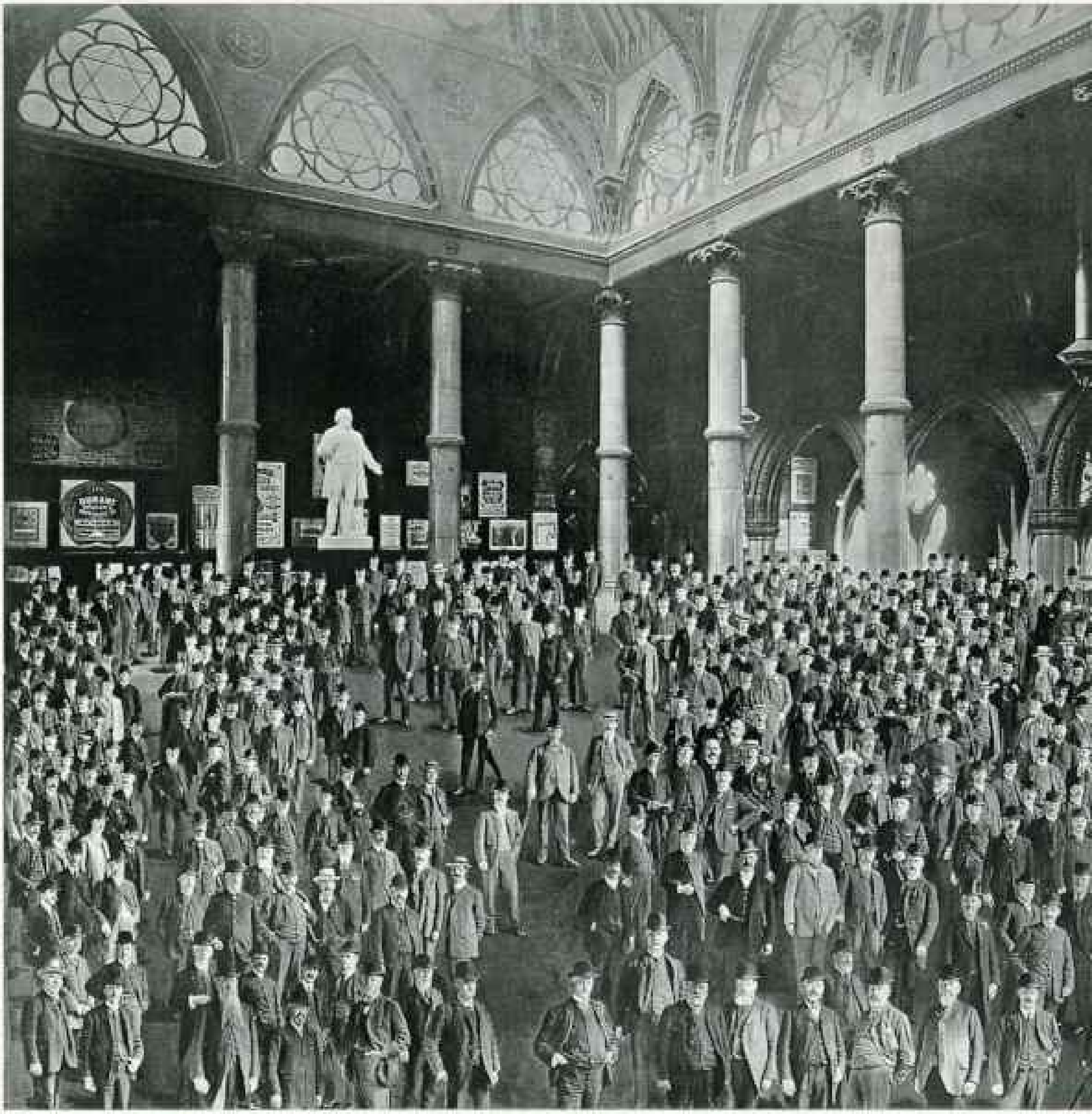
Cheviot
(MEDIUM)

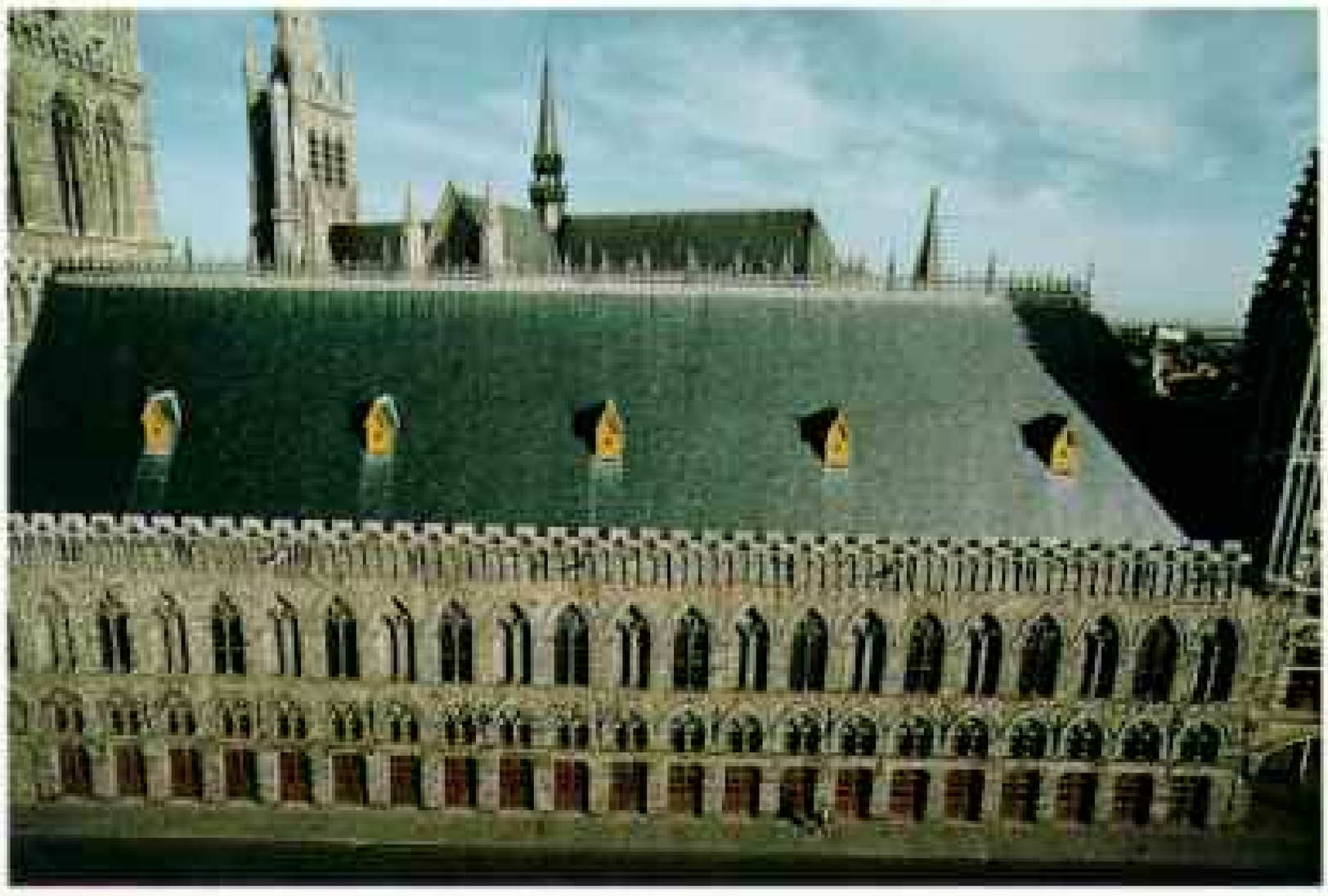
Southdown
(MEDIUM)

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.





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

BRADFORD INDUSTRIAL MUSEUM

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.

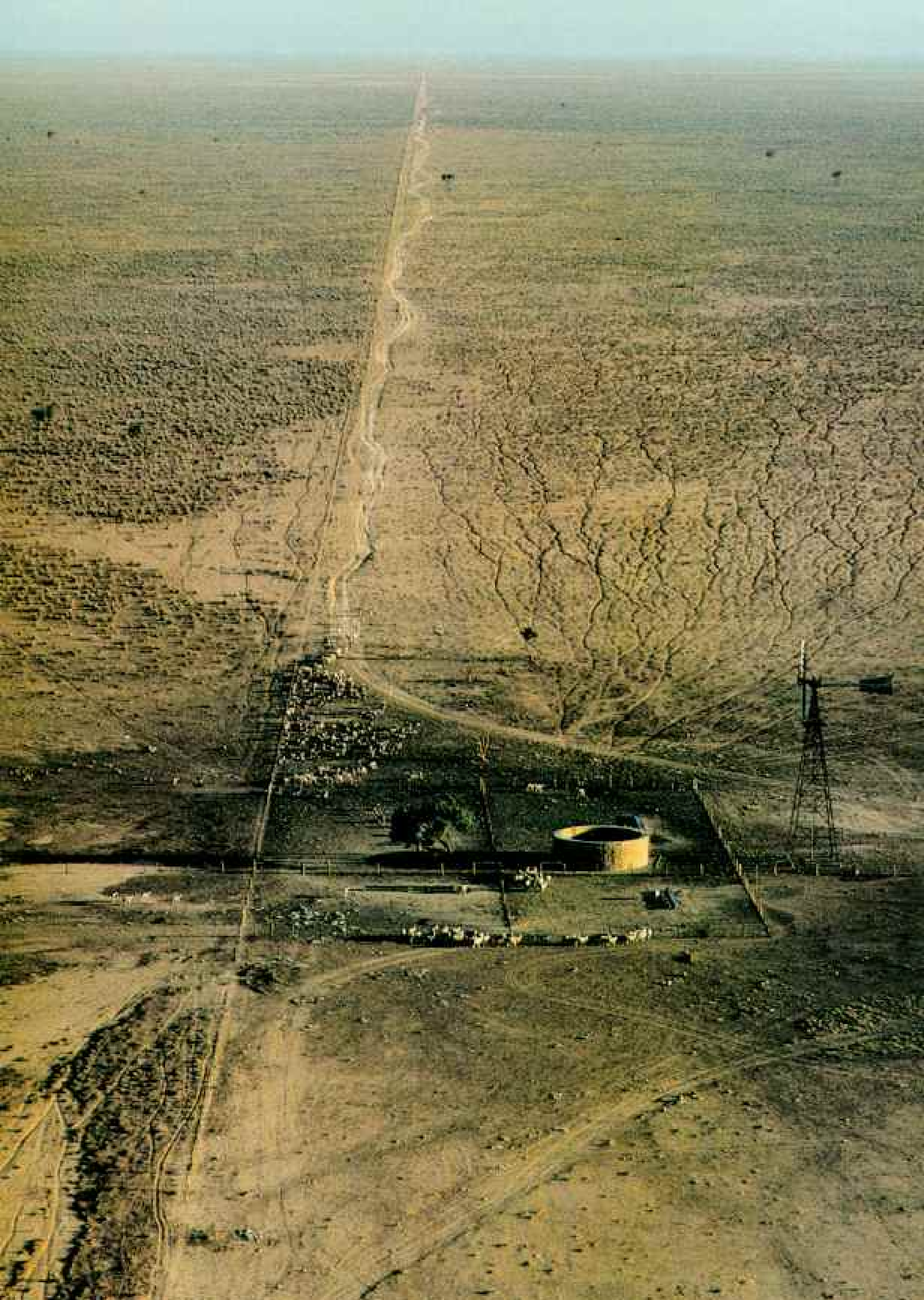
About the same time, big wool-consuming countries went to Australia for wool auctions. Recently I sat in on one in Sydney, watching the bids on wool bales displayed in the two-million-square-foot wool store—at 54 acres the largest wool warehouse in the world.

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.

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

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.



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.

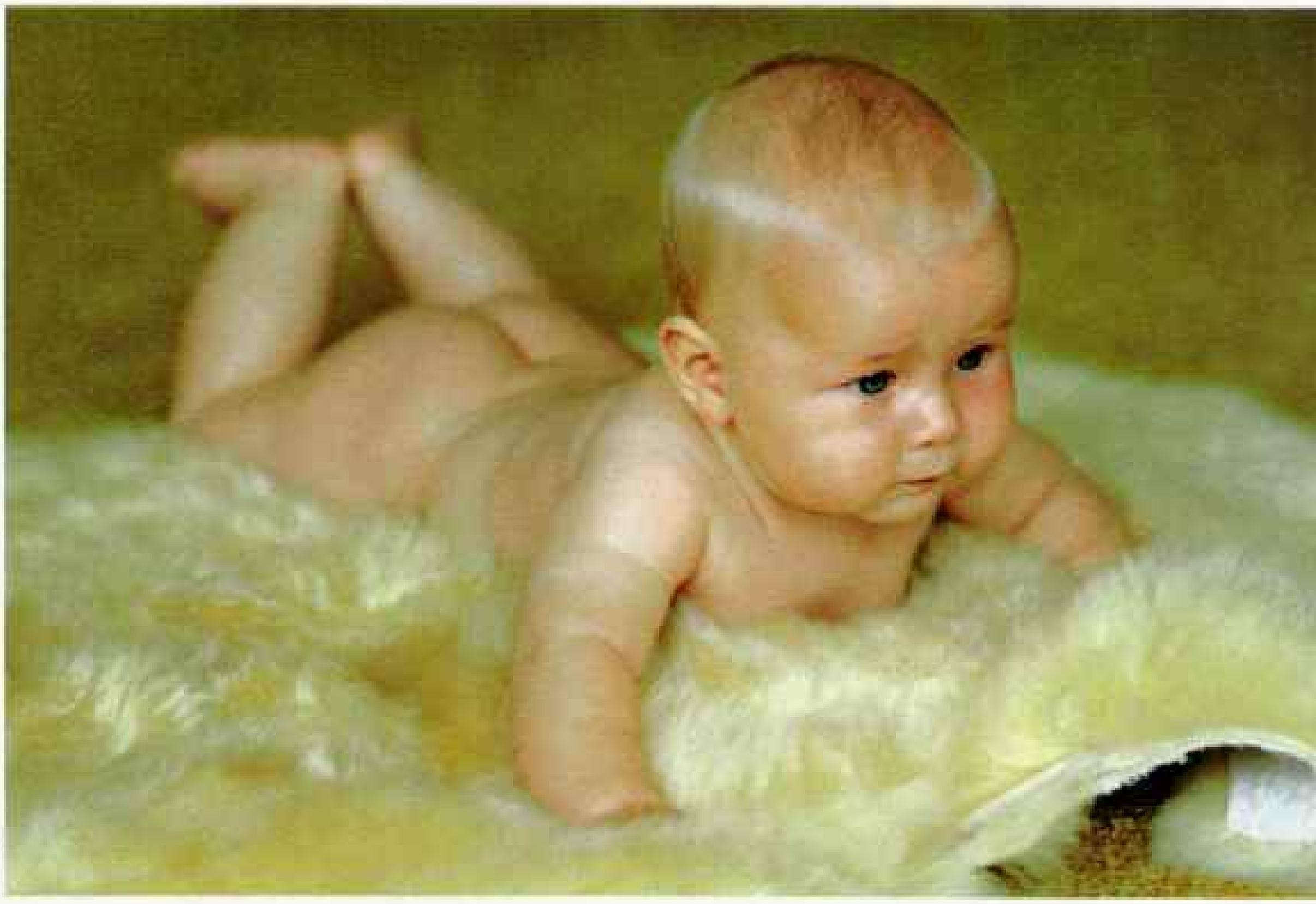
Australia's Commonwealth Scientific and Industrial Research Organization is also trying, through genetic engineering, to produce sheep with the ability to grow better wool. They want to develop genes that will enable sheep to produce sulfur-amino acid, a key nutrient in wool growth, and not have to rely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

HIS HOME away from home, a felt kepenek shelters a semi-nomadic shepherd while he pastures his flock in the hills of western Turkey. Serving as coat, tent, and blanket, the waterproof kepenek, worn throughout much of Asia, is so stiff and sturdy that it literally stands on its own. Shaped from a single piece of felt, it bears little decoration other than the maker's name on the outside and the owner's name inside.

The rise and fall of empires is intertwined with wool, in particular felt. Wool clothing allowed nomadic tribes to expand into extremes of terrain and climate. Wool was so pervasive in the lives of Asian nomads that the Chinese called their territory in the fourth century B.C. "the land of felt."

When cultures clashed, wool rode into battle. Borrowing from the nomads, Chinese warriors carried felt shields and wore felt boots. "Felt in the shape of a tower," according to the Greek historian Strabo, formed the headgear of the Persian army. Roman armies traveled with flocks and set up looms to clothe the soldiers. In Turkey tribesmen elevated newly elected chieftains on a felt rug. And when empires fell, felt became tribute. In the eighth century A.D. a king of Ceylon presented the Chinese imperial court with several pieces of white felt as an offering.

LIVING

IN WOOL

PHOTOGRAPHED AT THE NATIONAL MUSEUM OF ANTHROPOLOGY AND ARCHAEOLOGY, LIMA, PERU

FABRIC OF RITUAL and the routine, wool has been used in Peru for at least 3,000 years. Textiles were a prized commodity to the ancient Peruvians. Social distinctions were signaled by cloth, and the Inca maintained textile storehouses in urban centers. Weaving motifs reflected daily concerns and had religious significance. But the passage of centuries has obscured the meaning of some symbols, and today many weavers offer no other reason for a design than to say, "We have always done it so."

From above, clockwise: A mummy bundle dating from around 500 B.C. and preserved by desert sands of the Paracas Peninsula may have been a woman weaver dressed for burial with her backstrap loom. A woman on the island of Amantani in Lake Titicaca slings her load in woolen knapsacks. Part man, mythical beast, and bear, a ukuku mask of sheep and alpaca wool is worn by young men at a coming-of-age ceremony.

A Chayas Indian couple from the mountains southeast of Cuzco wear traditional wool garments during market day in Macusani, a trade center for alpaca wool.

WOOL BLENDS seamlessly into the world of a Peruvian woman whose child slumbers to the rhythm of her spinning. "Children here seem to learn woolworking skills by osmosis."

says the photographer. This spindle is sometimes turned counterclockwise to make yarn for cloth edges in the belief that the reverse spin wards off evil spirits.

DISTINCTIVE and distinguished, an elaborate felted szür (left) is worn over the shoulders like a simple shepherd's kepenek by a member of a Hungarian competition horse-and-coach team. Homespun djellabas keep two schoolboys in a Moroccan village (right) cool in summer, warm in winter.

Father and son on the grasslands of Qinghai Province in China wear fleece-trimmed coats. These seasonally nomadic Mongolian people live in felt yurts while tending sheep, goats, and camels in summer; they move to mud houses in winter.

A virtual security blanket swaddles an infant (below right) on the Umatilla Indian Reservation in eastern Oregon. Manufactured by Pendleton Woolen Mills of Oregon, these trade blankets have been cherished by generations of American Indians. Among many tribes Pendleton blankets represent a currency of their own and are pawned in pinched times. Given as gifts at birth, they are kept for life and form a burial shroud at death. Wool, the common thread binding cultures, binds both ends of man's life as well. □

Slender snake boats prepare to race during a Hindu festival. Equally competitive in daily life, the people of Kerala, one of India's smallest states, lead the nation in education, health, and—some say—ambition.

Kerala

Jewel of India's Malabar Coast

By PETER MILLER NATIONAL GEOGRAPHIC SENIOR EDITORIAL STAFF
Photographs by RAGHUBIR SINGH

THE FIRST MONSOON CLOUDS of the summer cascade over tea pickers near Munnar on one of the world's highest tea plantations at 2,130 meters (7,000 feet). The annual

monsoon rains, vital to all of India, reach the subcontinent first in Kerala. The Western Ghats, a coastal range, form the eastern boundary of the narrow state.

THE PAPERBOY was just leaving as I stopped by a village tea stand one morning in this small, tropical state on the southwestern coast of India. A cow lay on the ground in front of the stand, flicking its tail in the humid air. On the porch a scrawny kitten mewed.

Inside, a group of men were going over the latest news. Nothing happens in the morning in Kerala until everyone, from rice worker to university professor, takes a quick look at a newspaper. There are more than 40 published in the state, reflecting the fact that the people of Kerala are by far India's most literate. They also tend to be outgoing, ambitious, and extraordinarily skeptical.

"It says here that two parties have claimed victory in the district election," one fellow grumbled in Malayalam, Kerala's rapid-fire language. "How is that possible?"

"It's the same old story," said another. "As soon as one party realizes that it has lost, it stages a big victory celebration. Happens all the time."

I had to laugh. The sarcasm was so typical of Kerala humor. The politicians may play their games, he was saying, but they won't fool the people. How could they, I thought. When it comes to flamboyant politics, Kerala has seen it all.

In 1957, shortly after the state was established, Kerala surprised the world by electing a Communist administration, the first in India. Leftists praised the vote as an example of communism's new direction down "the parliamentary road to socialism." But national leaders in New Delhi reacted to the vote like a left jab to the chin, labeling Kerala a "problem" state.

That label has stuck through 14 state ministries—some Communist, some non-Communist. Few have lasted through their full five-year terms. And six times the central government has stepped in to take control after political conditions became chaotic.

Last year Kerala baffled political experts again by electing another Communist-led government. The victory—engineered by party leader E.M.S. Namboodiripad (below)—meant that, for the first time since independence, none of India's four southern states would be run by the dominant national party.

In a country as vast and diverse as India, where 750 million citizens speak 16 official languages and more than 800 dialects, such maverick behavior can prompt nervous questions. Were the bonds holding the nation together beginning to loosen? Had India's young prime minister, Rajiv Gandhi, lost his touch? And finally, what is it that makes the people of Kerala so unpredictable?

FORMER CHIEF MINISTER E.M.S. NAMBOODIRIPAD, LEFT, AT A COMMUNIST RALLY IN 1987

To look for some answers, I returned to Kerala last April for my third visit in four years. I knew from the start that it was a place like no other in India. Coconut palms throw cool shadows over quiet backwater canals. Fishermen in wide, conical hats glide by in jet black canoes. A peasant up to his knees in a flooded rice field hitches a water buffalo to his plow. It looks, for all the world, like India's corner of paradise.

Its villages are visibly cleaner and its cities less slum-ridden than in almost any other part of that nation. Health standards are high. Compared with the national average, Kerala's birthrate is a third lower, infant mortality two-thirds less, life expectancy 14 years longer. Virtually every child attends at least a few years of grade school, which is free through the tenth year. All this is the legacy of enlightened Hindu rulers who during the 19th century encouraged European missionaries to spread learning among their subjects.

A stroll beneath the palm trees, however, reveals that paradise has gotten crowded. Roads overflow with humanity. Overloaded buses, listing like boats ready to capsize, swerve around groups of schoolgirls. Trucks honk at bicyclists. Motorized rickshas graze old men pulling oxcarts. Young herders swat at cattle to keep them out of traffic.

With more than 29 million people, Kerala is one of the most crowded rural spots on earth.

Kerala

Demand for pepper and other spices stimulated trade between southwest India and distant lands more than 2,000 years ago. Because of these early contacts Kerala became the first destination in India for Christians, Jews, and Muslims, whose descendants have added a cosmopolitan flavor to the state's 29 million people, who are predominantly Hindu.

Stretching 580 kilometers (360 miles) along the Malabar Coast, it squeezes a population larger than California's into a tenth of the space. Most of the people live along the coast, laced by 41 rivers and more than a thousand canals.

THIS MORNING I'm standing beside one of those canals in the town of Kottayam, waiting for a ferry to Alleppey. The route will carry me through a predominantly Communist district. I hope to learn something about politics from my fellow passengers.

It's going to be another scorcher. At 7:30 the thermometer reads 33°C (92°F). A drought has tormented the region for months. For the second year in a row the September monsoon rains have failed, and drinking water has all but vanished. Village women leave jugs along the road each morning in hope that a government water truck will come by to fill them.

When the ferry arrives, about 40 people get on. Two young girls in pigtails and matching pink dresses plop down on a hard, wooden bench beside their brother, who asks their mother for money to buy a comic book from

ENTERPRISE AND INGENUITY fill the streets of Trichur (above), where candy shops such as Brown Sweet Palace and McNaulds Sweet House compete for one's eye. Spotted elsewhere in the city: the Unemployees Lucky Centre, a lottery-ticket booth run by out-of-work laborers; Singsong Radio Spares; and Urgent Dress Cleaners.

The brightest stars of India's space program gathered outside Trivandrum in 1963 to found the nation's first rocket research center, where a small weather rocket is readied for launch (right). Scientists here at the Vikram Sarabhai Space Centre, named for the father of Indian rocketry, designed the booster that put India's first satellite into orbit in 1980 from a launch site in the state of Andhra Pradesh. Today they are working to perfect a five-stage vehicle capable of carrying a payload three times as large. In its initial test flight in 1987, the rocket failed, falling into the sea.


XAGON
Tailors
PRAKASH
THE FBI BOY
McNAULDS SWEET HOUSE
Carona
Carona
CHER
STANES TYRE
AND RUBBER PRODUCTS LTD.

a dockside vendor. The family is Christian, dressed in their finest for Maundy Thursday. Kottayam is the center of the state's Christian community, the largest in India.

I am reminded that Kerala is a medley of faiths: three-fifths Hindu, one-fifth Muslim, one-fifth Christian. Most of the last are "Syrian Christians," so called because they follow liturgies and traditions derived from Eastern Orthodox missionaries. Tradition says the Apostle Thomas converted Hindus here in A.D. 52. Historians agree that Christians have lived here since the fourth century.

Muslims claim a mosque was founded during the lifetime of Muhammad. Jews have lived here since the first century A.D. Recently the colony has almost disappeared as young members have emigrated to Israel.

Now the ferry chugs past hundreds of ducks; their down blankets the water like petals of flowers. The boat's engine, which has no cover, is making a racket. But through the din I hear a gentle voice singing. It belongs to a grizzled-faced old man sitting near the back of the boat, who rocks back and forth as he sings.

The canal serves many functions. In it, one fellow bathes; another brushes his teeth with his finger; a woman throws back her long black hair after having washed it; a girl lifts a jug of water onto her shoulder.

The landscape now opens onto an endless expanse of rice fields, which are separated from the canal by dikes. At one stop some rice threshers come aboard. I talk with an old woman named Pennamma. "I can't remember how long I've worked in the fields," she says, covering an embarrassed smile with her hands. "All my life, I guess."

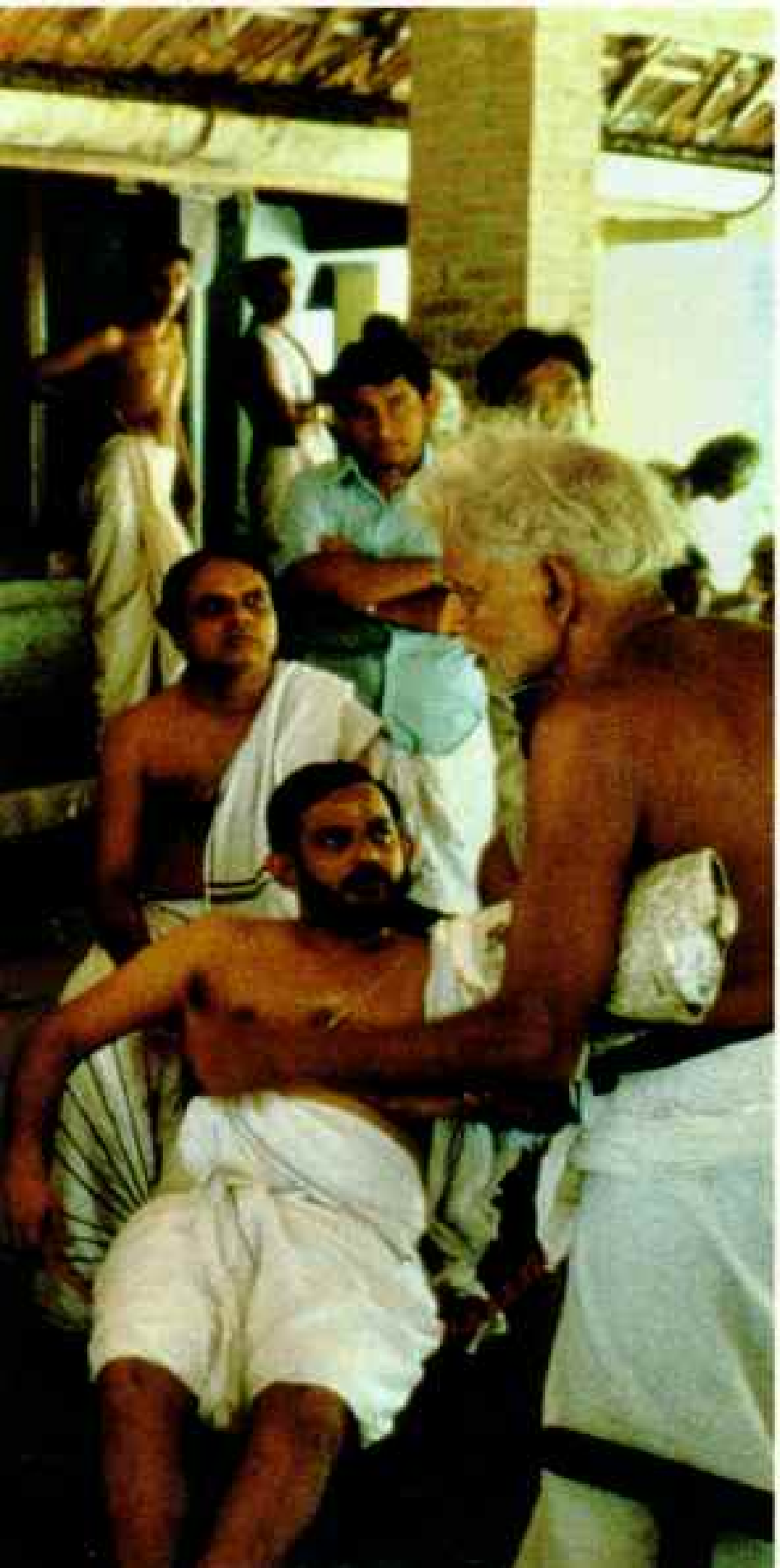
She wears a faded green blouse and a rough muslin cloth wrapped around her waist and over her shoulder. Like many agricultural workers, she belongs to the "scheduled classes"—formerly called the untouchables.

"Haven't I seen you before?" she asks. Her skin, like that of many south Indians, is the shade of mahogany. "Maybe not," she says quickly. "White-skinned people look very much the same to me."

Minutes later eight men step aboard carrying curved knives and aluminum lunch containers. They are toddy tappers, who collect nectar from the tops of coconut trees. This liquid, after fermenting, forms the basis of a popular alcoholic drink.

One of the men talks enthusiastically about the achievements of the Communist Party: "Before they organized us, our pay was very low. Now we have a strong union. We make 40 to 50 rupees [$3.50 to $4.25 U. S.] a day and are working to get a retirement pension." He added proudly, "We have a strong belief that the betterment of the working class is due to the Communists."

We leave the canal, start across Vembanad



MEMBERS OF THE HIGHEST Hindu caste in Kerala, the Namboodiris, the Olapmanna family gathers annually near Palghat. Their joint family home (top), called an illam, was once the hub of a grand estate. Kerala's caste system, now officially dismantled, was India's most complex. Namboodiris traditionally served as priests, scholars, and art patrons but today enter many vocations.

TO THE ROAR OF THE CROWD, riders on gold-caparisoned elephants lift shocking pink parasols at the Pooram festival in Trichur. Gathering at the Vadakkunnathan temple

each spring, devotees of the largest temples in the area compete with one another to display the brightest parasols, loudest fireworks, and most magnificent musicians.

TRANSFIXED BY FLAMES, a dancer assumes the personality of a Hindu god during a ritual dance called Theyyam (left). In this role he bestows blessings upon a village near Cannanore. Praying to a snake deity for an early marriage, a woman near Alleppey performs a trance dance (bottom) as a pullavan, or priest, sings and plays a fiddle.

Lake, and approach Alleppey. Most of the passengers are napping. I hear the gentle singing again behind me. But this time it seems much closer. I turn around to see the old man shuffling down the aisle toward me.

"*Yesu ennum yende daivom,*" he chants in Malayalam, "Christ is the God in my life." He works for a Pentecostal church, he says.

"I was once a Communist too. I spent two years in jail for fighting the police. I was thoroughly beaten up. I couldn't even lift my body. Then some missionaries came to see me, and I said to myself, if I get better, I will join them. And I regained my strength.

"I was going to be killed, but I was saved to serve God," he says. "That is why I sing now wherever I go." He shrugs a little smile and sings all the way to Alleppey.

WHERE WAS KERALA HEADING? Were the Communists on the rise? In Trivandrum, the state capital, I sought out political experts. "I would not describe the election as a Marxist victory," said P. Aravindakshan, a correspondent for the *Week*. "The leftists won by less than one percent of the vote. More important was the desire of the people to separate politics from religion."

The previous administration, he explained, had gone too far in granting special favors to Christians and Muslims—such as tax exemptions and government jobs. Hindus felt neglected, and the Communists capitalized on their resentment.

The public was also voting against corruption, said V. Krishna Moorthy of the *Hindu*. "Almost every minister in the government had been accused of misconduct. Everyone knew it. Voters are well informed."

As for the defeat of Gandhi's Congress (Indira) Party, M. D. Nalapat, former editor of *Mathrubhumi*, said: "It was a blow, but it wasn't a rejection of his leadership. There is still a great deal of goodwill for him. The message was: Don't take us for granted."

Kerala politics are complicated. The state was created in 1956—from the Malabar district of Madras state and the principalities of Cochin and Travancore—to unite peoples speaking Malayalam. But the people—called Malayalis—remain deeply divided.

"Caste and religious community are still the dominating factors," Nalapat said. "There are schools, banks, political parties, and who knows what else devoted exclusively to communal groups."

No party commands a majority; the three largest—Congress (I) and two Communist factions—compete for alliances with 14 smaller ones. Thus, I was told, "the Communists have compromised and compromised until there is

THE "POPE OF KOTTAYAM," Mar Baselios Marthoma Mathews I, awaits the arrival of Pope John Paul II in 1986. As the Catholicos of the Malankara Syrian Orthodox Church, he leads one of India's largest Christian sects. Kerala's Christians trace their roots to the Apostle Thomas, who is said to have visited here in A.D. *52.*

nothing left to the label. They have become just another political party."

I repeated this to E.M.S. Namboodiripad, General Secretary of the Communist Party of India (Marxist). In his late 70s, he is a small man with wispy white hair and a stammer. He answered: "Some maintain that communism means no compromise. But life is compromise. And communism is life. The question is not whether to compromise, but to compromise on what, and with what objective."

In any case the party and Mr. Namboodiripad have a claim on many poor Malayalis. As Kerala's first chief minister, he introduced land and education reforms. Later administrations followed his lead, passing more reforms, so that today hundreds of thousands of peasants own the small plots they cultivate.

I DECIDED to take my political questions to commonfolk and so traveled to the village of Panathura in the south. It stretches five kilometers along a narrow, sandy islet on the Arabian Sea. Waves pound the beach on one side, while a quiet lagoon stagnates on the other. Chickens and goats stroll shady paths; children push one another on rope swings; the dirt in front of every door shows the mark of a broom.

I crossed over the lagoon in a small boat poled by a ferryman and was met by a group of fishermen. They usually sail out each morning, but rough seas had kept them ashore.

I asked an older man for whom he had voted in the last election. "Everybody told me to vote for the 'palm,' so I did," he said, referring to Congress (I), whose symbol is the open hand. "Also, they paid me two rupees."

The other men laughed at his candor. But they admitted that the corruption issue had hurt the palm.

At a shady spot between some houses I joined a group of women making coir rope fibers by pounding coconut husks. Village women often seem shy, but their modesty can hide strong opinions.

"This seems a beautiful spot," I ventured. "Are you happy to live by the sea?" "Happy?" squawked an elderly woman. "This is a horrible place. The mosquitoes are so big they carry you away. And the sea is so close, I am always afraid. When the monsoon comes, the waves will rush right into the village."

The other women laughed but became serious when talk turned to their needs. "The

former government made a lot of promises," said Kamala Devi, a young woman with intense dark eyes. "They told us they would build a bridge across the lagoon, but they didn't. When people get sick, we have to take them to a mainland hospital. A baby was born on this side a few weeks ago because there wasn't a boat to take the mother across.

"That's why a lot of us voted for the Communist candidate," she said. "We are not Marxists. We just wanted something different. We were hoping for a change of luck."

A CHANGE OF LUCK. That's exactly what happened for a group of laborers in northern Kerala in 1984. Their futures changed one morning when one of them struck a buried pot with his shovel. Out spilled 1,200 gold coins, all shining as brightly as the day they were minted.

To the workers the coins represented an unimaginable fortune. To archaeologists who later examined some of them, they were an equally precious window on Kerala's ancient past. I was curious about that past and so looked into it.

"I heard that a few of the coins may be here in Trivandrum," a government official told me, adding that it was illegal to buy or sell such national treasures. "You might ask at a shop on Mahatma Gandhi Road."

It was early evening when my friend Babu Varghese and I set off to find the coins. Trivandrum is a city of wide, treelined boulevards and ornate, red-brick buildings trimmed in white. The air was pungent with woodsmoke and diesel exhaust. Traffic poured through narrow streets, sounding like a recording of jungle noises played backward.

The shop was dark, but a clerk led us into a back room and to a telephone. Babu called the shop owner. Speaking loudly in Malayalam, he assumed his most authoritative voice. When he hung up, he smiled.

"It's all arranged," he said. "The owner will bring the coins to your hotel room later this evening."

"Wonderful," I said. "How did you manage that?"

"Simple. I told him that you were a famous American coin expert, and that money was no problem."

Knowing nothing about coins, I had a hollow feeling in my stomach when I met the shop owner that evening. But the feeling vanished

AN OPULENT NEW MOSQUE near Quilon (top) reflects the influence of the Persian Gulf, where many Muslims from Kerala have found work in recent years. In Cochin a caretaker at the 16th-century synagogue holds copper plates from around the eighth century that offer protection to the Jewish community by the local Hindu ruler.

RACING AGAINST THE CLOCK, a team of farmers drives a pair of oxen across a flooded rice field at an annual competition near Quilon. One member of the team clings to a leveling plank to hold it down. Despite the fact that Kerala's economy is mainly

agricultural, the state grows only about half the rice it needs. Most families supplement their diet with less nourishing tapioca.

when he placed a small coin in my hand. It was a Roman gold piece, inscribed on one side with the name "Caesar Trajan Hadrianus" and an image of the emperor Hadrian.

Even I could see that I was holding a shining link to antiquity.

The coins had been used 1,800 years ago—probably by Greek merchants on behalf of the Romans—to buy the pepper that flourished on the moist, seaward slopes of the mountains called the Western Ghats. They conducted their business at the port of Muziris, described by a Tamil poet as "where the beautiful large ships of the Yavanas [Greeks], bringing gold, come splashing. . . ."

Trade between India and the West was already many centuries old. Goods from south India had reached the Middle East as early as the third millennium B.C. But the discovery of the monsoon winds by Greek sailors about A.D. 45 made it possible for ships serving Rome to sail from the Horn of Africa to Kerala in only 40 days. This shifted the focus of the spice trade from north Indian ports to Muziris, which Pliny called the "first commercial center of India."

Stimulated by the Roman demand for exotic goods, Indian and Malayan merchants also pushed east during this period, collecting silk cloth and cinnamon from China and pearls, precious stones, and tortoise shells from Indonesia. These they brought to Muziris and other south Indian ports to be loaded onto Greek and Arab ships. Positioned midway along the spice route between Rome and China, Kerala thrived as an international meeting place.

More than a thousand years later the lure of spices and luxury goods attracted a new crowd of merchant adventurers to south India: the Portuguese, Dutch, French, and English. And like their earlier counterparts, they left behind in Kerala their foreign religions and ideas.

"You are interested in this coin?" the shop owner inquired at last. "The price is only 15,000 rupees [$1,250]."

"It's beautiful," I said as I led him to the door. "But if you don't mind, I'll have to think about it."

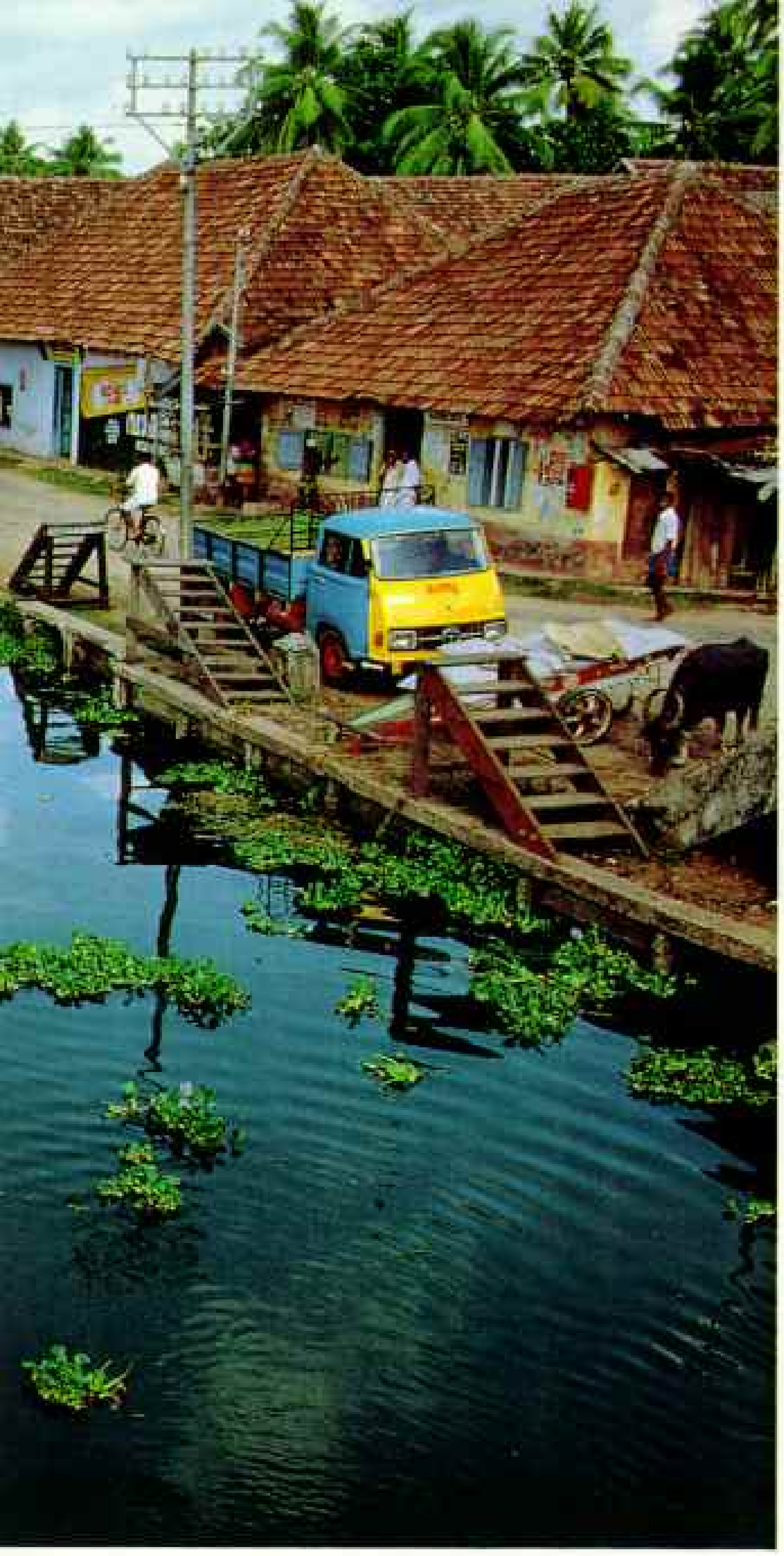
And think about it I have, for the coins help to explain how Kerala grew to be so different from the rest of India. "We have always been oriented toward exports," said economist T. N. Krishnan. He added that Cochin, after Bombay, is India's busiest west coast port.

"Today our products are rubber, coffee,

tea, cardamom, cashews, pepper, and seafood." He might have added talent and enterprise, because the state's most valuable export in recent years has been people. Malayalis working in Arab nations of the Persian Gulf and elsewhere have pumped ten billion rupees (840 million dollars) a year into Kerala's otherwise sluggish economy.

There is no shortage of qualified workers. "Our 228 colleges produce thousands of degree holders every year," said former Chief Minister K. Karunakaran. "But we don't have enough industry to accommodate them." In a work force of eight million people, unemployment is 18 percent. One in three persons is underemployed.

The expatriates are the lucky ones. Young men returning from the Persian Gulf spill from Trivandrum Airport every afternoon. Many wrestle with prayer rugs wrapped around stereo systems, and they tip lavishly. In the waiting crowd, wives dressed in their best saris



POOR MEN'S TRUCKS, country boats haul coconuts, pepper, rice, and other heavy cargoes from villages to waterside warehouses in Alleppey (left). Connecting a web of rivers and lagoons, the canal system reaches 13 kilometers (8 miles) inland from the coast. Signs in Cochin (above) advertise the spices that made Kerala famous in the ancient world.

search for husbands they haven't seen in a year or more. Fathers of unmarried girls cast appraising eyes on the quality of luggage carried by prospective sons-in-law.

When the petro-rupees from the gulf started pouring in, Malayalis spent them on big houses, cars, videotape recorders. The change was dramatic in Muslim villages of the north, where the grip of poverty was still tight.

More recently, as oil producers struggle with a poor market and political unrest, these workers have begun to look to the day when the money will stop. "My employer is not renewing my contract," said K. P. Soman, a 27-year-old office worker who had spent the past five years in Saudi Arabia. "Most of the new people are coming from Bangladesh and the Philippines. They will work for less."

The only one of seven brothers and sisters with a job, Soman had been sending back money to his wife and his parents. "Now that will have to stop."

A STRONG ARM AND LONG HOURS turn rotten coconut husks into coir fibers (left), which are twisted into ropes and other products for sale. Every resource of this tropical land is exploited, every patch of ground cultivated. On a narrow strip between paddy and canal, a farmer dries rice beside a haystack used for cattle feed.

STILL, IT'S HARD TO KEEP a Malayali down. "We are go-getters," said one former resident. "We are the kind of people who are willing to relocate, learn new languages—a well-educated, mobile group."

"We're born hustlers," agreed a Kerala man. "We've taken the best of different cultures—Tamil, Karnataka, Arab, British, Portuguese—and used them to our advantage. We're pushers."

I saw a lot of that push all around me in Kerala. I saw it in the cocky way Malayali men leave their shirts unbuttoned halfway down their chests, and in the jaunty twist they give to their skirtlike dhotis. I found it in Malayali women, in their brightly colored skirts and in the flowers they tuck into long, braided hair.

At the spring Pooram festival in Trichur, I discovered just how competitive Malayalis can be. From 6 a.m. one day till noon the next, they stage one of India's most lavish celebrations. It takes place at the temple dedicated to Lord Vadakkunnathan, one of the roles the Hindu god Siva takes as protector of the world. The festivities begin leisurely but build through the day as smaller temples compete with processions and musical events.

Then comes the rivalry between the two major temples. Festival director Balakrishna Menon explained: "Both will try to display the largest elephants, the best musicians, the most beautiful parasols, the most astonishing fireworks. It costs each temple a fortune—at least 200,000 rupees [$16,800]."

The rivalry is so intense, the details so secretive, I was told, that a husband and wife from different temples might not sleep together for a month before the festival.

I was nearly crushed when I followed a crowd through a gate into the main temple. I was pushed up against dozens of hammering drummers. Cymbalists and clarion trumpeters added to the din. At dusk the two temples' elephants squared off against each other in a ceremony called the divine *durbar*. More than 200,000 people jammed the temple grounds.

The scene unfolded like an epic battle, with two facing rows of 15 elephants each. To the roaring approval of the crowd, riders on one row of elephants lifted shocking pink parasols, sewn from the finest silks, with gold tassels around their rims. Not to be outdone, riders from the other temple raised baby blue parasols, and the crowd roared again. For an hour each side unveiled parasols of increasing complexity and beauty.

I wondered who was winning the competition. Different spectators offered different answers. Yet the longer I watched, the more I grew to understand that it didn't matter. For the people taking part, as well as those looking on, the true joy was in the competition—one performed in the presence of the gods.

THE PAST, of course, helps explain the present; and I was interested in Kerala's ancient caste system—India's most complex. Some castes were so far apart in status that a person of a high caste could be polluted merely by seeing someone of a low caste. The caste called the Nairs were traditionally warriors, like the samurai of Japan. Nair men recall their former position by practicing *kalaripayattu*, Kerala's martial art.

I watched students practice in Trivandrum.

Their bodies glistening with fragrant sesame oil, they strode in pairs across the dirt floor, kicking straight up as they went. The first two fighters were armed with short sticks. They cautiously circled each other, keeping low, then suddenly clashed in a flurry of clacking blows. The next pair sparred with five-foot-long bamboo poles, and the last with curved metal daggers and small round shields.

"Isn't this dangerous?" I asked their teacher, Govindankutty Nair.

"Danger is always part of it," the master replied. "Risk is always there. But you must remove fear by constant practice. Mentally and physically you must be very pure. It is ritualistic, as in a temple. Otherwise the weapon may cheat you. You must have confidence. Doubt is dangerous."

Nair women were also noted for their strength and confidence. Families were matrilineal. A set of sisters, their children, and their daughters' children often lived together in a single household called a *tarawad*. A man's wealth passed to his sisters' children.

Women formed many liaisons in a system that probably evolved from the caste's military function—the men were often away fighting. When a man paid a woman a visit, it is said, he left his weapons outside her door to warn off other callers. Such practices vanished long ago, but the independent streak lives on, not only in Nair women but also in other Malayali women, who frequently hold professional positions unheard of elsewhere in India.

"I remember my mother-in-law," said Kamala Das, a Nair poet who was herself raised in a tarawad. "She used to be like the rising sun, you know? In the courtyard of her home there was a balcony, and she used to sit there in the afternoon and settle disputes. Everybody, all the poor people from the locality, would come with their grievances, and it was a court. She would see that guilty ones were flogged right in front of her. Whipping! You know, tying them up to a jackfruit tree and whipping! Women were that way—so strong!"

I spoke with Das in a house built like a traditional tarawad, with four rooms surrounding a small inner courtyard. She wore a blue dress, tortoiseshell glasses, a diamond in her nose. A pistol in a holster—to protect her from a rival political group, she told me—was slung across the back of her rattan chair.

We talked about her poetry; she was nominated for a Nobel Prize in 1984. Her poems offer a glimpse into the heart of a Nair woman: "One night I woke to find age stick a crusty finger down my throat. . . . Love is youth time's magic; am I still entitled to its lure?"

But what impressed me most about Kamala

A LEAP OF FAITH is made by students of kalaripayattu, the martial art of Kerala, as they put absolute trust in master teacher Govindankutty Nair (left, at center). Studied today by men of many backgrounds, kalaripayattu was practiced centuries ago by the Nairs, a warrior caste who served like the samurai of Japan.

Devoted to education, Kerala spends 40 percent of its budget on schools, giving every opportunity to students like these at Providence High School in Kozhikode (above).

Das—aside from the pistol—was her sense of independence. "It's very difficult for Nair women to believe that we need to be liberated," Das said. "We can't get very emotional or strident because we have never felt we were slaves. All the major decisions were ours."

"I WILL TELL YOU what makes us different," travel agent Babu Varghese said in exasperation one afternoon. As my translator, Babu had listened patiently as I asked the same questions many times about the Malayali personality. Unhappy with the answers he heard, he vented his frustration.

"The difference is that we Malayalis are proud of who we are. We are not apologetic in the least about being Indian, not in the way you sometimes see up north. We are the true Indians, never conquered or put into submission by outsiders."

As he spoke, the power failed in his office for the third time that day, and once again we sat in darkness. A helper brought in a small candle that barely illuminated its own stand. Yet none of these things daunted Babu as he gave voice to his south Indian pride.

It was the same pride I discovered at the Jumbo Circus in Trivandrum. Kerala gave birth to one of India's first modern circuses in 1901, when a martial-arts teacher in the village of Tellicherry opened a training school for performers. Ever since, Tellicherry people have been running many of the circuses in the country, and the Jumbo Circus is no exception. Besides the four brothers who own the show, 50 of its 300 employees are from Tellicherry, including an acrobat trainer named Sukumaran and his daredevil wife, Radha.

I talked to the couple one morning in their small tent. Sukumaran was sitting on a cot at one end while Radha prepared lunch at the other, grinding coconut and spices for a fish curry. A lion was growling nearby, and the wind carried the smell of elephants.

"We knew each other when we were young," Radha told me. "But he was working for one circus and I for another. So we arranged a marriage, and I came to join him."

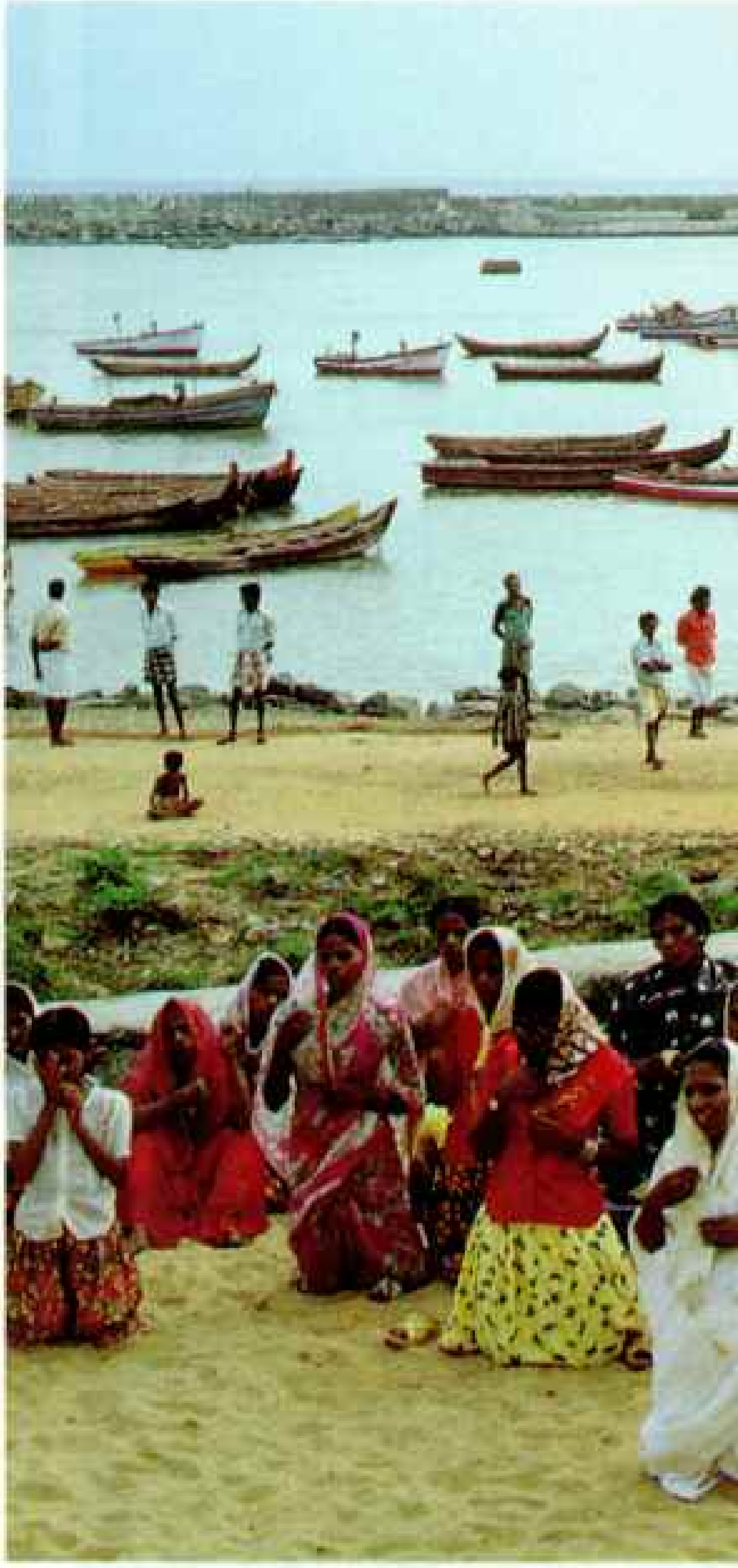
"Radha fills in for other performers when they are sick," explained Sukumaran. "She can do anything in the circus."

"Just give me ten hours to learn the act."

"She even does the jeep jump."

I'd seen the show and remembered the stunt. A driver launches a jeep at high speed off one ramp and lands it on another some distance away.

"Isn't that normally a man's job?" I asked.



THE SAFETY of their husbands fills the prayers of Christian fishermen's wives at Vizhinjam. Among the poorest groups, they are also among the most devout. "People in Kerala have higher expectations than others in India," said one priest. "But they are also satisfied with the simple things—a house, some land, a peaceful way of life."

"Yes, but the audience appreciates it more when I do it."

"Tell me something," I asked Sukumaran. "When you first joined the circus, did you think it would make you rich?"

He looked at me thoughtfully and started to give an answer. But Radha had already made up her mind. Make money in the circus? The tent was filled with the sound of her laughter.

I saw that Malayali self-confidence once again—as clear on Radha's face as it was on those of girls walking barefoot to school, of young men racing motorcycles to work, of fishermen pushing catamarans into the surf. It was the face of India's crowded corner of paradise: ambitious, skeptical, and unpredictable.

I wondered what lay ahead for Kerala, where I had seen so much life, such variety, conditions so much better than elsewhere in India. Nature had even given her a green mantle, while so much of the subcontinent was a dusty brown. Could she finally throw off the contentiousness, the skepticism, and make life even better? Farewell for now, paradise. □

TWENTY-MINUTE EXPOSURE MADE AT LAS CAMPANAS OBSERVATORY WITH A 16-MM LENS AND A SPECIAL CAMERA PROVIDED BY STEWARD OBSERVATORY MIRROR LAB

SUPERNOVA DEATH OF A STAR

By ROBERT P. KIRSHNER

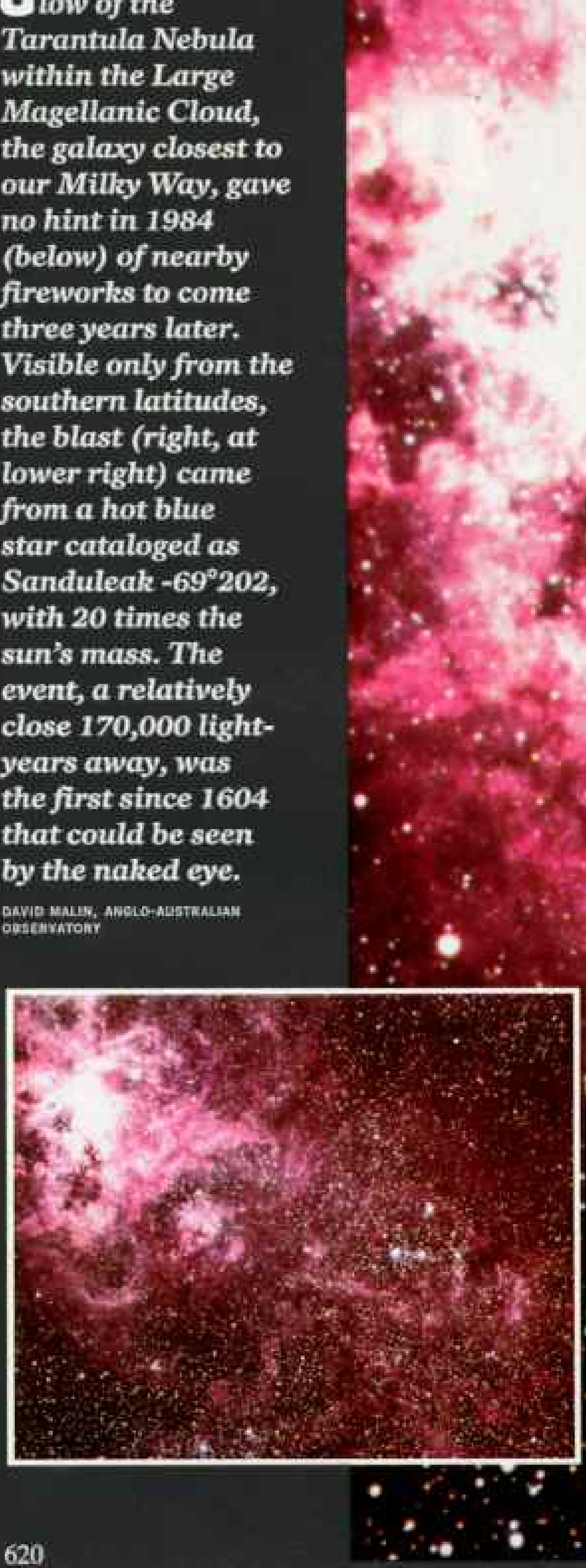
Photographs by
ROGER H. RESSMEYER
STARLIGHT

"Many small stars congregated . . . like to two clouds."

Thus one of Ferdinand Magellan's crew, on the first voyage around the earth, described the southern Pacific sky on a clear night in 1520. On such an evening nearly five centuries later—February 23, 1987—an explorer of the stellar sea, Ian Shelton, opened an observatory's roof atop a Chilean peak. Below the panoply of the Milky Way he sought one of the Portuguese navigator's patches of stars, the Large Magellanic Cloud, seen just to the right of his modest ten-inch telescope's lens in this re-creation. And there he found a new fierce light in the sky created by the titanic explosion of a nearby star. This supernova now leads scientists on a spirited voyage of discovery into the very nature of the universe.

Glow of the Tarantula Nebula within the Large Magellanic Cloud, the galaxy closest to our Milky Way, gave no hint in 1984 (below) of nearby fireworks to come three years later. Visible only from the southern latitudes, the blast (right, at lower right) came from a hot blue star cataloged as Sanduleak -69°202, with 20 times the sun's mass. The event, a relatively close 170,000 light-years away, was the first since 1604 that could be seen by the naked eye.

DAVID MALIN, ANGLO-AUSTRALIAN OBSERVATORY



IN THE EARLY morning hours of February 24 last year, Oscar Duhalde took a break from his work at the 40-inch telescope at Las Campanas Observatory on a mountaintop in northern Chile. He put on a kettle to heat water for coffee and went outside to look at the southern sky. Duhalde glanced at the soft, fuzzy glow of the Large Magellanic Cloud (LMC), the nearest galaxy to our own, just 170,000 light-years away and visible only from the southern latitudes. It was as pleasant a sight for him as it was for Ferdinand Magellan, who spied it on his 1520 voyage to circumnavigate the globe and after whom the galaxy is named.

"I know very well the Magellanic Cloud," Oscar would say later. "I saw a new object there but didn't know what kind of object it was." The troublesome light faded from his mind as he reentered the observatory, which is operated by the Carnegie Institution of Washington, D. C.

Nearby, the University of Toronto's resident observer, Ian Shelton, was pursuing his hobby—the same as his work—astronomy. Using a little ten-inch refracting telescope, he had been photographing the LMC for several nights. Now he finished a new exposure, developed the plate, and studied it. He noticed something strange: a bright star near the center, one that didn't belong there. Curious, Ian went outside to see if this bright spot on his plate was a real object. It was. He could see it.

Ian walked over to the team manning the 40-inch telescope and asked, "What would you think of a new star in the LMC?"

Something clicked in Duhalde's brain. "Oh," said Oscar, "I saw it at two o'clock."

The whole troop marched outside to look at the supernova—a dying star, the first seen by the naked eye in 383 years—a new ornament for the southern sky and the key to unlocking many mysteries of stellar life and death.

Others observed the star. While Tuesday was dawning in Chile, it was night in New Zealand. Amateur astronomer Albert Jones was in his backyard, diligently monitoring the skies with a telescope. He was working on the Large Magellanic Cloud when he saw a star he had not seen the night before—the supernova.

The night before in the Warrumbungle mountains of New South Wales, Australia, Robert McNaught had photographed the LMC and developed the film, but hadn't inspected his data. When he did examine his pictures from February 23, he found that the supernova had already brightened to the threshold of human vision 16 hours before Ian Shelton took his picture.

Word of the discovery reached me the morning of the 24th at my office at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. The news came, as so often in astronomy, via the grapevine—a phone call from my colleague Craig Wheeler of the University of Texas. I didn't believe him—I had been fooled by pranksters before.

I headed for Brian Marsden's office. He runs the Central Bureau for Astronomical Telegrams, the official clearinghouse for such bulletins. One glance told me the report was correct. Brian was simultaneously talking on the telephone and typing on a computer, while a Teletype chattered in the corner. Word of SN 1987A—the first supernova of the year—was going out to the astronomical world.

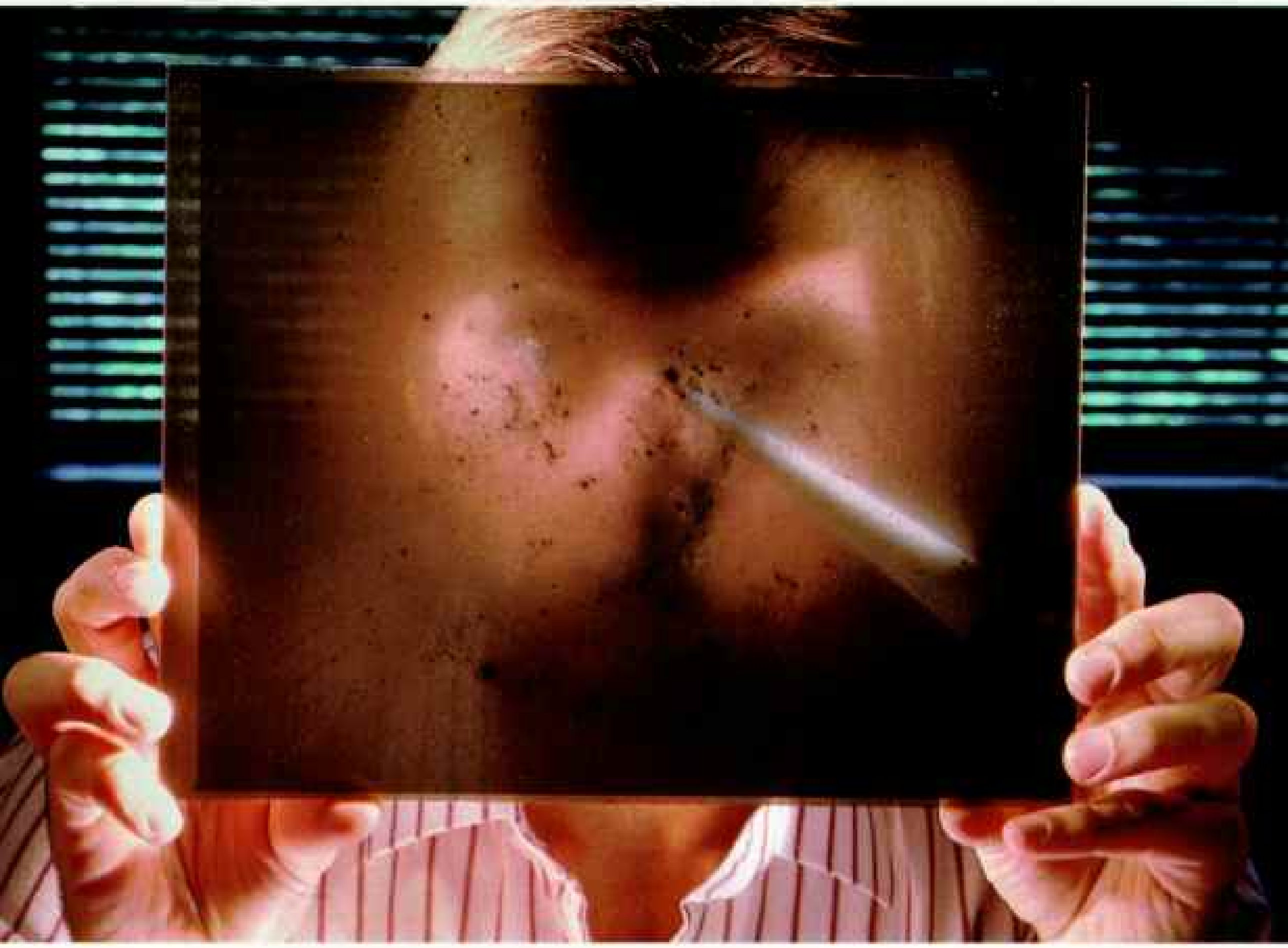
THIS WAS THE BIG EVENT we astronomers had been waiting for: the violent death of a nearby star, one close enough to be visible without a telescope. At this range our instruments are able to gather data 10,000 times faster than we can from the 20 or so supernovae found each year in more distant galaxies.

Not since 1604, when German astronomer Johannes Kepler viewed one, has a supernova been seen by the naked eye. Kepler had no alternative, since the telescope wasn't applied to astronomy until 1609. But today we have a variety of sophisticated devices mounted in satellites, airplanes, balloons, even in huge tanks of ultrapure water hidden in the dark galleries

Author ROBERT P. KIRSHNER is Professor of Astronomy at Harvard University. ROGER H. RESSMEYER is the founder of Starlight, a San Francisco-based firm specializing in the photography of stars—stage, screen, and celestial.

"I was sure that it was a flaw, but it was no flaw."

IAN SHELTON



SUSPECT SPOT on a photographic plate led to the discovery of the supernova by Ian Shelton, then the University of Toronto's resident observer at Las Campanas Observatory in Chile. No bright image had been there before. Was it real? He walked outside. It was.

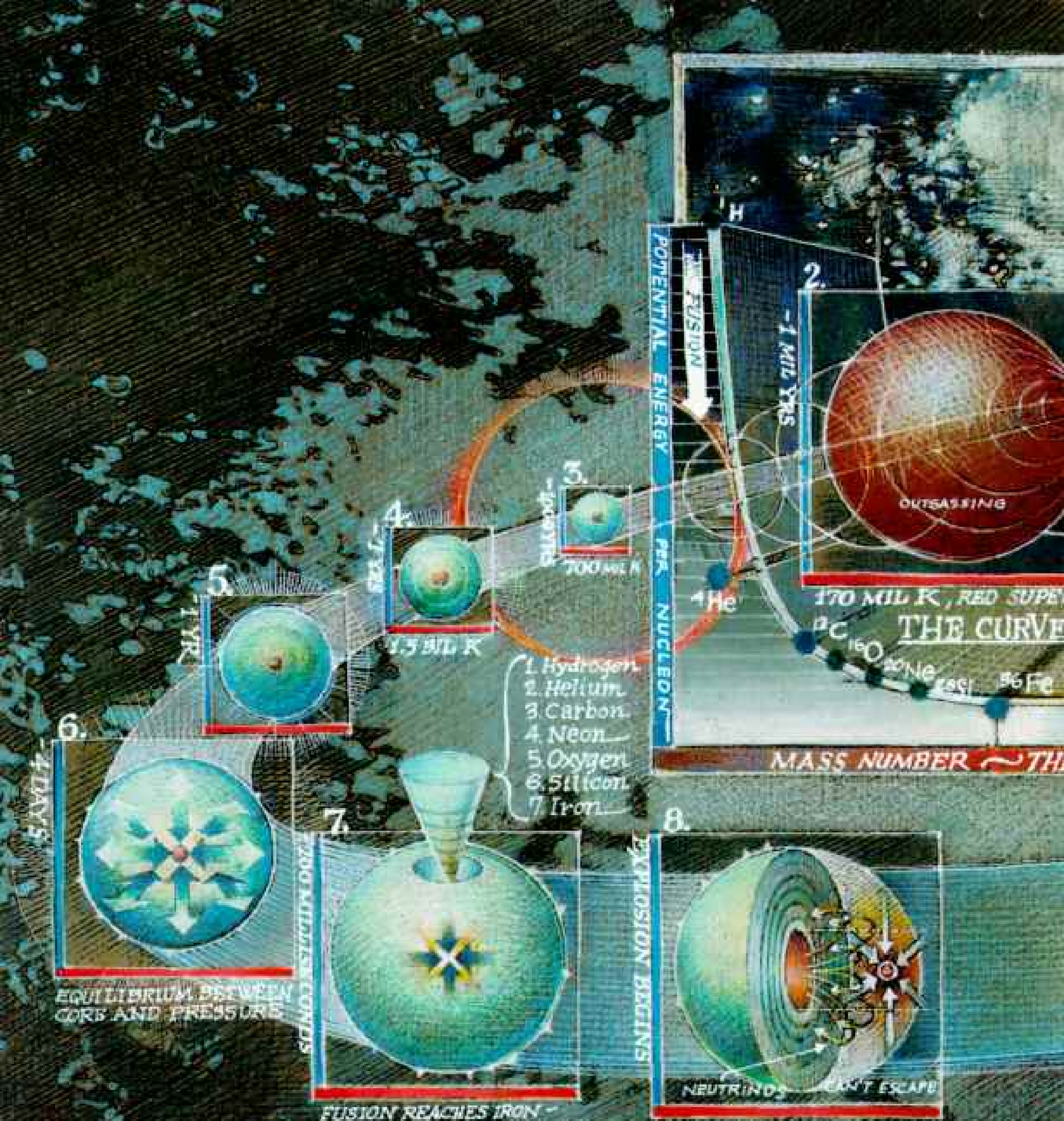
of underground mines. The collapse of a massive star's center releases a flood of energy, cooks new elements, and produces the grand spectacle of a single star shining more brightly than a hundred million suns. That is the object these tools would dissect, testing our theories and adding to our knowledge of the origin of matter in the cosmos.

I spoke with Yoji Kondo at the National Aeronautics and Space Administration's Goddard Space Flight Center, outside Washington, D. C. To aid in my studies of supernovae, I apply each year to observe with NASA's International Ultraviolet Explorer (IUE) satellite. The satellite is always busy, scheduled for use 24 hours a day. But as IUE project scientist, Yoji needed little convincing to point the satellite at the supernova.

Next I called the South African Astronomical Observatory near Sutherland, Cape Province, where darkness would soon fall, to make sure they had read their telex; alerted my own center's radio astronomers, who began plotting how to observe in the Southern Hemisphere; and asked my colleague Jack Hughes, recently returned from Japan with a rudimentary grasp of the language, to call a Japanese group operating *(Continued on page 629)*

BATHED BY MOONLIGHT during a ten-minute exposure, Cerro Tololo Inter-American Observatory (CTIO) appears laced with trails created by red flashlights carried by astronomers to protect their night vision. Operated by a consortium of United

States universities under sponsorship of the National Science Foundation, CTIO is ideally situated in Chile to view the supernova. The observatory immediately pointed several of its telescopes toward the exploding star.

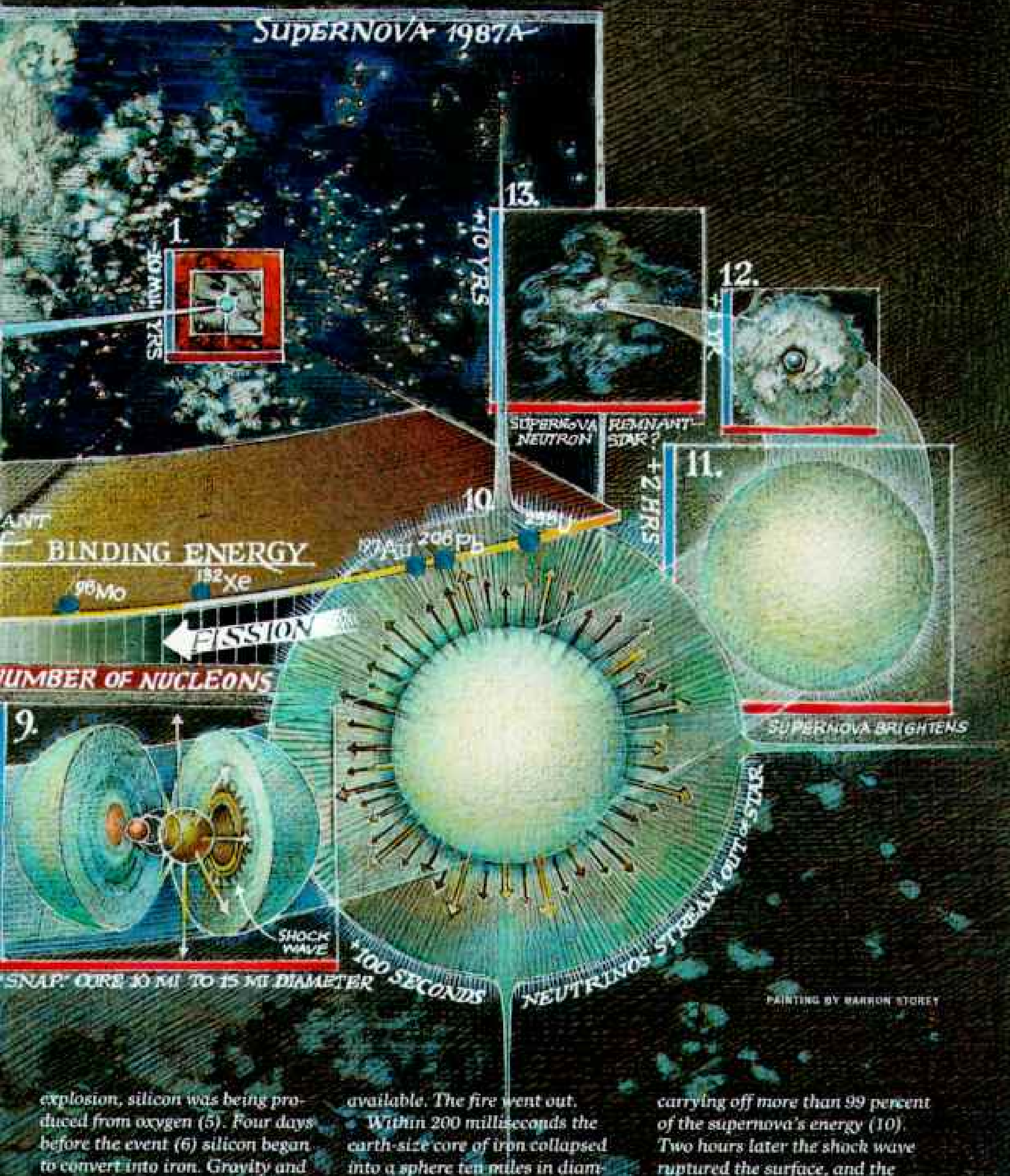


Ten million years before the light heralding its death burst out toward us, a hot blue-white star was consuming its hydrogen at a profligate rate, converting it to helium (1). Gradually it swelled into a brighter, cooler, red supergiant (2). Gravity squeezed the star's core, driving its temperature to 170 million kelvins (K), equivalent to 170 million degrees Celsius above absolute zero. Helium began fusing into carbon and oxygen, and the star exhaled some of its surface gas, which lingered like a halo as the supergiant contracted.

The binding energy that holds atomic nuclei together can be released in two basic ways. In complex atoms with many nucleons (protons and neutrons), like uranium, this energy is released by fission—splitting the atoms. In simpler atoms such as hydrogen, nucleons are combined into larger nuclei—fusion—a process that also releases energy. The curve of binding energy indicates the potential energy available from each nucleon of various elements.

One thousand years before its death the star's core had reached 700 million K (3), and carbon began fusing into neon.

The reaction quickened. The core's temperature climbed to 1.5 billion K (4) some seven years before the supernova, consuming neon. By about a year before the



explosion, silicon was being produced from oxygen (5). Four days before the event (6) silicon began to convert into iron. Gravity and pressure from nuclear reactions were still in equilibrium.

A cone leading into the core depicts the composition of the star's layers (7). The core reached the point of no return after silicon completed its conversion into iron, nature's most stable element. No more energy was available. The fire went out.

Within 200 milliseconds the earth-size core of iron collapsed into a sphere ten miles in diameter (8). Particles called neutrinos were formed but could not escape. The core rebounded in a 20-millisecond "snap" to 15 miles across (9). An enormous shock wave ripped outward.

One hundred seconds after the collapse the neutrinos tore through the star's surface, carrying off more than 99 percent of the supernova's energy (10). Two hours later the shock wave ruptured the surface, and the supernova flared into incandescence (11).

A year later the brightness has dimmed, and we see a glowing cloud of gas (12). Within a decade we may detect the supernova's suspected legacy—an incredibly dense object known as a neutron star (13).

(Continued from page 623) a new X-ray satellite that might be used to good effect.

Similar scenes were played out at observatories around the world. An event that happens once in a lifetime—or, like this one, once in seven lifetimes—is cause for throwing even the most carefully contrived schedule into a black hole. The star exploded 170,000 years ago; it took that long for the signals to reach earth. But now there was no time to lose.

FROM THE START, SN 1987A presented puzzles. Astronomers lump supernovae into two categories. Type I supernovae have no hydrogen on the surface, and we believe that most derive from low-mass stars that erupt in a nuclear explosion. Type IIs come from massive, hydrogen-rich stars that collapse at the center. Which type was 1987A?

Finding out was the first order of business for the astronomers in South Africa, where it grew dark sooner than in Chile and where the skies were clear. Gathering the supernova's light with their telescopes, they spread it out into the colors of the rainbow in a spectrograph and used the pattern as an identifying fingerprint. The spectrum did not seem to show a signal for hydrogen, normally the most abundant element in stars. This indicated the supernova was Type I—very puzzling, since it occurred in a region of massive, hydrogen-rich stars. Another possibility was that the surface velocities of the atmosphere of SN 1987A were so high that hydrogen was not recognized.

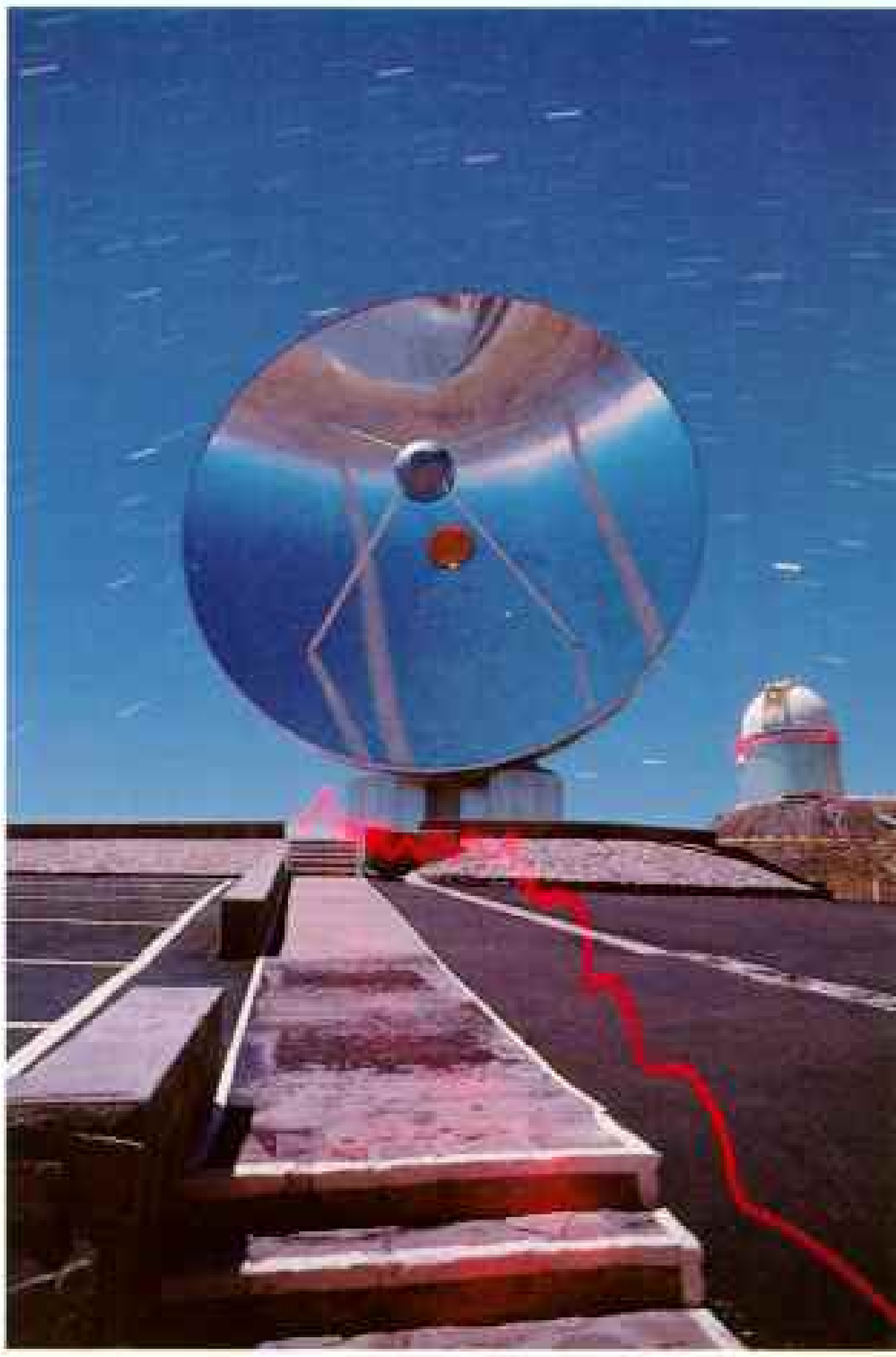
Night came to Chile, and I telephoned Mark Phillips at the Cerro Tololo Inter-American Observatory, operated by a consortium of U. S. universities under sponsorship of the National Science Foundation. Mark has done valuable work on southern supernovae and knows Type I spectra well. But he was unsure what type of supernova his spectrum of 1987A showed. A long night's work dispelled his doubts. "It's Type II," he reported next morning. "The hydrogen lines are all there."

At least, I told myself, we know what we're dealing with. Dozens of Type II supernovae have been studied. But SN 1987A proved a maverick of its class.

By all Type II rules, 1987A should have grown in brightness during the next week or so, until it blazed as one of the brightest objects in the southern sky. Instead it reached only one-tenth its expected brightness, then cooled rapidly from hot blue to a deep ruby color in just a few days.

But its rate of expansion had been phenomenal. Our first measurements showed that the star's outer layers had been blasted off at a tremendous velocity: more than one-tenth the speed of light. On day one the ejected layers hurtled as far out from the point of explosion as the orbit of Uranus is from the sun.

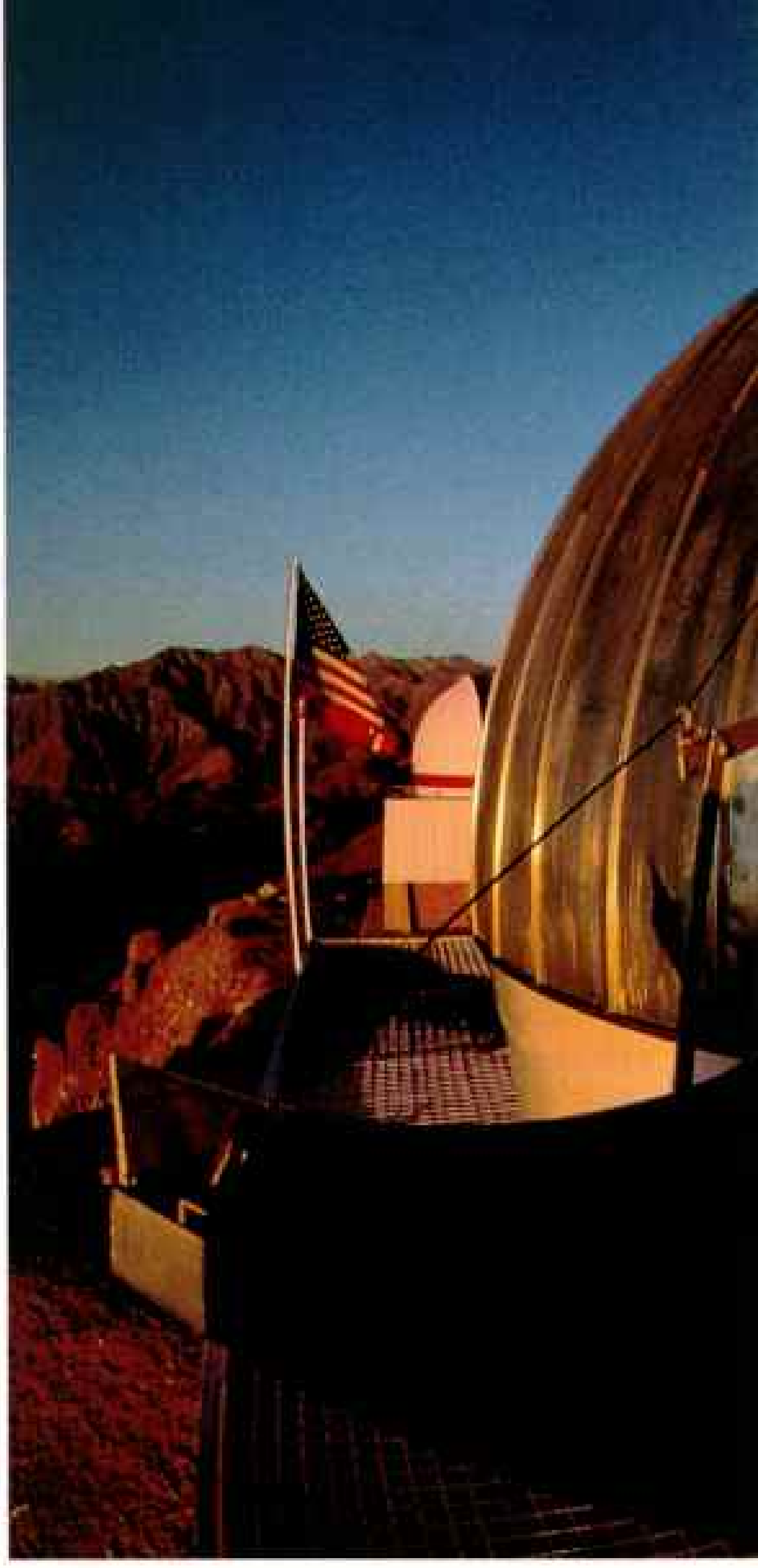
In these three ways—faintness, change of color, and high velocities—1987A did not resemble other Type II supernovae. It was like



OTHERWORLDLY when revolving during maintenance, a radio antenna at Parkes, New South Wales, Australia (opposite), detected signals from the supernova's shock wave as it collided with gas that had earlier blown away from the star.

Its near-perfect surface gleaming at the European Southern Observatory in Chile, a submillimeter telescope seeks supernova emissions of very short radio wavelengths.

TELESCOPIC SUNGLASSES were needed to protect even a small 16-inch instrument at Cerro Tololo, so bright was the supernova's glare. At sunset, research assistant Mario Hamuy prepares to attach a screen to the telescope.



hearing a familiar song sung in another language: recognizable without being understandable.

WE SET ABOUT identifying the victim. Because the Large Magellanic Cloud is nearby and has been intensively studied, we should have been able to tell what star exploded by looking at images taken before February 23. Accurate measurements of the supernova position showed that it was at exactly the same place as a hot blue star in an LMC catalog prepared in 1969 by Nick Sanduleak of Case Western Reserve University in Cleveland, Ohio. His list tabulated this prime suspect as number 202 in the group of stars 69 degrees south of the Equator. We call it Sanduleak -69°202.

The Sanduleak star has a close neighbor, so close that the two stars blend together in pictures of moderate quality. Following my request to NASA, George Sonneborn of the IUE Observatory had been watching SN 1987A. Because the supernova's ultraviolet radiation had plummeted a thousandfold, we were able to survey the scene of destruction. We expected to see only the neighbor star. We were shocked to find two stars still present! Could the Sanduleak star have survived?

When I suggested this possibility, Stan Woosley, a supernova theorist from the University of California at Santa Cruz, was more than skeptical. "If the Sanduleak star didn't blow up, the supernova came from a star just like it!"

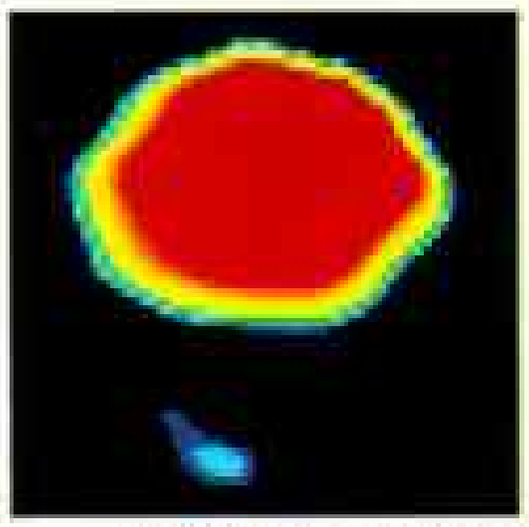
In the end the theorist's confidence was justified: Subsequent scrutiny showed that the Sanduleak star had possessed not one but two companions, both bright enough in the ultraviolet to be detected by the IUE satellite. Sanduleak -69°202, we knew now, had *not* survived.

The catalog listed its vital statistics. Sanduleak -69°202 was a hot blue-white star resembling Rigel, a bright, familiar star in the constellation Orion. It was about 20 times the mass of the sun, shining furiously with 100,000 times the sun's luminosity. Using its fuel in

Son of Supernova?

A MYSTERY SPOT near the dying star was detected last April, baffling observers. The spot, seen beneath the supernova in the image below, was 8 percent as bright as its neighbor, was about two light-weeks away from it, and could not have existed earlier.

The phenomenon was discovered by Costas Papaliolios (opposite, at left) of the Harvard-Smithsonian Center for Astrophysics.



HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS

To the four-meter telescope at Cerro Tololo Professor Papaliolios and graduate students Jim Beletic (at center) and Bruce Sams attach a new and highly sophisticated tool called a speckle camera. The speckle technique minimizes atmospheric distortion and can distinguish celestial objects close together, such as double stars, as well as the supernova and its Mystery Spot.

Although several creative theories were offered to explain the enigma, none proved conclusive. And by June the companion no longer could be detected, leaving only questions behind.

Messages from a dying star

DEDICATED EYE of amateur astronomer Albert Jones detected the supernova from New Zealand shortly after Ian Shelton first saw it. Over 40 years Jones has spent some 35,000 hours with his 12.5-inch telescope.

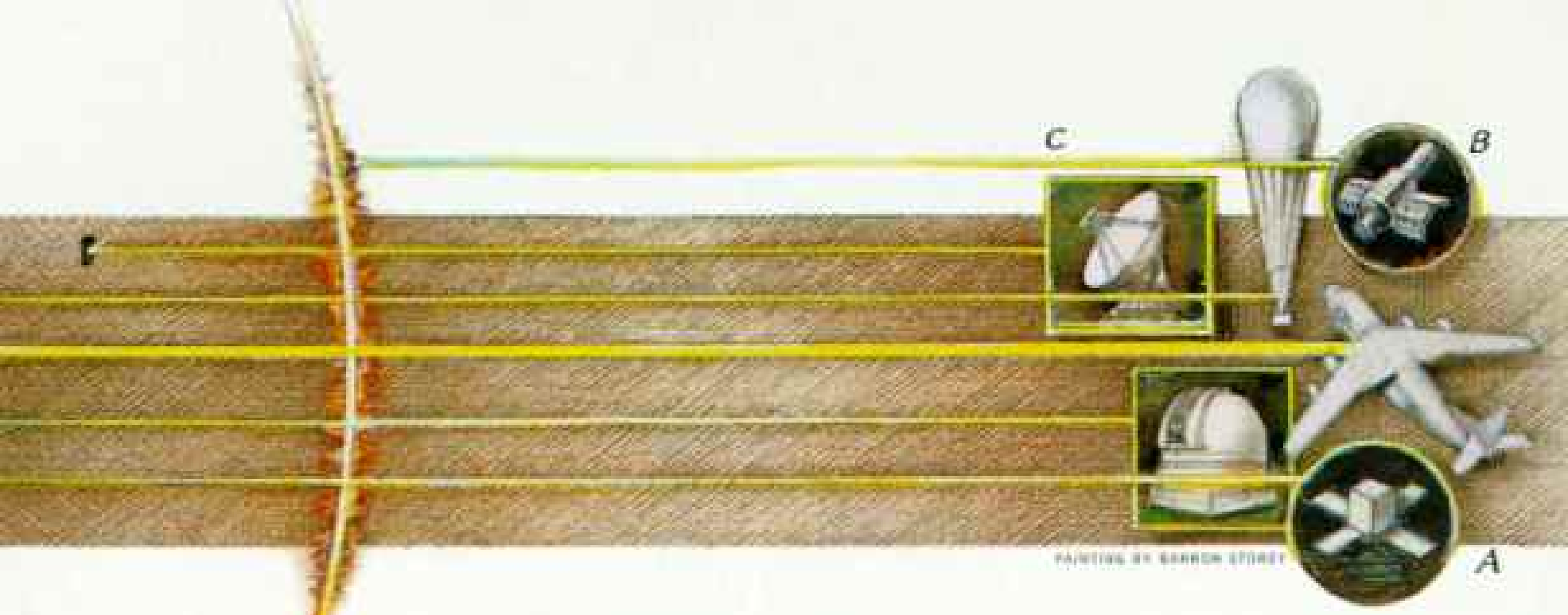
such a prodigal way, it could last for only about ten million years. While this is long compared with a home mortgage, it is just 1/1,000 of the estimated lifetime of the sun.

In size Sanduleak -69°202 was only 50 times the diameter of the sun—much smaller than we expected for the progenitor of a Type II supernova. Most are red supergiants, about ten times as large as the Sanduleak star. This compactness, we would discover, explained many of the supernova's unusual properties.

WHAT ARE THE EVENTS that lead a star like Sanduleak to explode? The answer is linked to the way stars generate energy, which is either by gravitation or by nuclear fusion.

A star is born from a cloud of interstellar gas and dust. As the protostar coalesces and contracts, it heats up from the release of gravitational energy. Just as Niagara Falls provides the potential to generate electricity from falling water, a star falling together generates energy that shows up as heat.

When the center of a star gets hot enough, a new source of energy becomes available: nuclear fusion. In a star like the sun the lightest, simplest kind of atomic nucleus—the hydrogen proton—combines with three other



PAINTING BY BARRON STOREY

Specialized tools look deep within the supernova remnant, where a neutron star may be spinning. It is surrounded by a mass of radioactive cobalt that produces gamma rays, which energize the glowing, expanding debris. The infrared radiation from that mass was seen by an airborne observatory (pages 636-37). Balloon experiments (pages 640-41) observe high-energy gamma rays, while Japan's Ginga satellite (A) detects X rays deflected from within.

Visible from earth-based telescopes, material from deep within the star races outward, already two and a half times the diameter of Pluto's solar orbit.

The gaseous remnants of the star's red-supergiant phase are studied by the International Ultraviolet Explorer satellite (B). Gas between the two fronts was perceptible with sensitive radio telescopes (C).

hydrogen protons to make the next simplest type of nucleus, helium.

The four particles bound together in the helium nucleus have less mass than the four hydrogen nuclei that went in. The balance shows up as "binding energy" in accordance with Einstein's oft quoted formula, $E=mc^2$. In this formula, c is the speed of light (186,000 miles per second), a very large number. As a result, a tiny loss of mass, m, results in a titanic release of energy, E.

This is the process that enables a hydrogen bomb to convert a mere 50 grams (about two ounces) of matter into the energy of a megaton explosion. It explains why a star like the sun can shine steadily for billions of years, permitting the steady evolution of life on earth.

The sun, however, is not massive enough to destroy itself as a supernova. It will probably end its life quietly, bloating briefly into a red giant, then shrinking to become a white dwarf—a solid star with the mass of the sun but the size of the earth.

Massive stars go on more reckless adventures, as in the history we have reconstructed for the Sanduleak star.

During its normal lifetime the blue supergiant fused hydrogen into helium at a frantic rate. The hydrogen core was exhausted in about nine million years, probably only a million years before February 23. The star's metabolism quickened. Squeezed by gravity, the core contracted and heated until the helium became thermonuclear fuel. Helium nuclei, fusing in threes, formed carbon and oxygen and released more energy, perhaps swelling the star's atmosphere.

DAVID ALAN HARVEY

EYEWITNESS: Oscar Duhalde (with author Robert Kirshner, at right), a telescope operator at Las Campanas, looked up and saw an oddity in the Large Magellanic Cloud—just before Shelton developed his plate.

Now the ashes of that stage fueled the runaway stellar furnace. The carbon produced neon and more energy. Gravitational pressure heated the caldron further, producing silicon and its neighboring nuclei of sulfur, argon, and calcium. In a final spasm the center burned to iron. This set the stage for the star's destruction.

At this point the Sanduleak star's structure resembled an archery target, with each ring containing the products of successive nuclear fusions: unburned hydrogen at the outside; helium that escaped burning in the next ring; then rings of carbon, neon, oxygen, and silicon; and, at the bull's-eye, the iron core.

Relentless gravity contracted and heated the iron core. But there was no more energy to be squeezed from nuclear fusion, nor pressure to resist collapse. Instead, some of the iron disintegrated into the lighter elements—a process that consumes energy and reduces support for the core.

The result was the catastrophic implosion of 170,000 years ago. The core, a very dense iron ball the size of the earth, collapsed in less than a second into an unfathomably dense object only about 15 miles across—a neutron star.

The energy escaped in a mighty blast of neutrinos—massless, chargeless particles produced in the unbelievably high temperatures of the forming neutron star. Like negligent children who escape from the kitchen without helping with the dishes, the neutrinos carried off enormous energy while contributing little to the explosion itself.

"The energy release of this event," observed theorist Stan Woosley, "is comparable to one second's output of all the stars and galaxies of the observable universe."

Although most of the energy came out in the form of neutrinos, about one percent was coupled to the rest of the Sanduleak star. This energy shocked and heated the archery-target rings, hurling them outward in the cataclysm that emblazoned the Large Magellanic Cloud.

The star's elemental ashes—silicon, oxygen, neon, carbon, and helium—along with unburned hydrogen will mix with the interstellar gas in the LMC, enriching it in heavy elements. Some new elements were synthesized in the explosion, especially radioactive nickel, which decays to cobalt and then to iron. Iron seeds probably grew into heavier and heavier elements; supernova explosions produce gold, lead, and uranium. (In fact, the explosions achieve the ancient alchemist's nightmare of turning gold into lead!)

IN THE SAME MANNER the generations of stars that lived and died in our galaxy before the sun was formed created an inheritance of heavy elements that was bequeathed to us. The carbon atoms in the ink of this magazine, the oxygen you're breathing as you read it, the calcium in your bones and iron in your blood are the products of stars.

This grand idea, that we are literally made of star stuff, is embodied in the popular song "Woodstock" by Joni Mitchell: "We are star dust, billion-year-old carbon." The death of stars is part of the origin of life.

Eventually the shock wave of a star's explosion may trigger the collapse of nearby dense clouds of gas to begin the cycle of stellar life again.

This sequence of events is so exotic yet so central to the chemical evolution of the

LEAPING into the Australian night, a sounding rocket—stage separation showing near the top—boosts an X-ray telescope above the atmosphere, seeking emissions from the supernova's core. Recovered downrange, it had recorded no X rays, although space-based instruments did so earlier.

universe that we should check it in every possible way. Is it true that a massive star generates heavy elements, crushes its core into a neutron star, and emits most of its energy as massless neutrinos? Can those bizarre neutrinos really carry off in a few seconds as much energy as a hundred suns generate in the age of the universe? Is this history—or a scientific fairy tale?

The way to find out is through observation. SN 1987A afforded us this opportunity.

The idea that supernovae might form neutron stars was suggested in 1933 by two Pasadena astronomers, Fritz Zwicky of Caltech and Walter Baade of Mount Wilson Observatory. A key prediction that stems from this idea got its first observational test in 1987 using giant tanks of water sequestered deep in underground caverns in Ohio and Japan.

At the IMB (Irvine-Michigan-Brookhaven) facility, sheltered from background radiation in a deep salt mine near Cleveland, 7,000 tons of ultrapure water make up a huge neutrino detector (pages 642-43). Lining the walls of the tank are 2,048 light sensors. Although neutrinos interact with matter so weakly that they can pass through the earth like ghosts and even penetrate a light-year of lead, a few might interact with the protons and electrons that make up the water. These would produce brief flashes to be picked up by the light detectors.

On February 23, at 7 hours, 35 minutes, and 41.37 seconds Universal Time, the IMB detector recorded the first of eight neutrinos. At essentially the same time, in a zinc mine near Kamioka, Japan, the similar Kamiokande II machine snared 11 events. This was three hours before Robert McNaught's photograph that showed the brightening of Sanduleak -69°202 and a day before Ian Shelton developed his plate.

The number of neutrinos detected, the duration of the neutrino pulse, and the energy of the neutrinos all matched very well the predictions of neutrino emission during a core's collapse to a neutron star—an amazing triumph of scientific imagination stretching back to the ideas of Zwicky and Baade.

From estimates of the magnitude of the supernova's hail of neutrinos, I calculate that a hundred billion would have struck every square inch here on earth. Judging from the limited number of reactions seen in Ohio and Japan, I estimate that roughly five million of the earth's five billion people would have harmlessly interacted with a neutrino. *If* you were awake at the proper moment—2:35 a.m. eastern time, February 23—and *if* your eyes happened to be closed, you may have caught one neutrino in the eye and seen—behind the closed eyelid—a flash of light from the exploding supernova.

In his poem "Cosmic Gall" John Updike imagines the intrusive effects of neutrinos:

At night, they enter at Nepal
And pierce the lover and
his lass:
From underneath the bed
—you call
*It wonderful; I call it crass.**

There are only 13 seconds' worth of neutrino data to study, only 19 neutrinos from the Kamiokande and IMB detectors combined. But they have led to more scientific publications than the neutrinos themselves number, and they have changed the way we look at supernovae.

There are many other improvements in astronomical equipment since that last nearby supernova was seen in 1604, and these devices

SEEKING HEAVY ELEMENTS fused in the blast, a NASA modified C-141 took off from Christchurch, New Zealand, carrying an infrared telescope to 41,000 feet, above most of the atmosphere's water vapor. From the airborne observatory astronomers saw emissions from nickel, cobalt, and iron.

*Copyright © 1960 by John Updike.

MILE-LONG EAR, the Molonglo Observatory Synthesis Telescope (MOST) in southeastern Australia was the first radio telescope to observe the supernova. Officer-in-charge Duncan Campbell-Wilson (here flanked by vehicle trails) heard rumors

of the event from amateurs, abandoned his project of the moment, and made the most of his opportunity. Such telescopes will be listening to confirm the presence of a neutron star in the supernova's core.

can observe the event for more than 13 seconds. Their results help build an intricate picture of the exploding star. One way to study it is from the outside looking inward.

FOR A MONTH after the explosion was first detected, radio astronomers in Australia recorded signals that indicated a faint new energy source at the site of the supernova. A blue supergiant like the Sanduleak star often loses some of its surface gas in a stellar wind; for the previous 10,000 years it had been exhaling a thin vapor. The star's explosion created a powerful shock wave running through this thin gas—it was this that the radio astronomers picked up.

After the initial neutrino burst, most of the energy emitted by a supernova in the first year comes out in the form of visible light. SN 1987A spread a feast for optical telescopes in South Africa, Australia, and Chile. Scientists were able to map out the motion and energy flow through the expanding surface, enabling us to study the structure of the star and to examine elements hidden deep inside.

These studies answered two key questions about SN 1987A—the high velocities of its expanding gas and the relative dimness of its light, both unusual properties in a supernova. Because Sanduleak was a hot blue star, it had a fairly small radius when the core collapsed. Its surface had to expand 20-fold before the light could escape easily from the interior. Much of its energy, therefore, went into motion, and less into light.

Measurements of surface energy showed that the supernova brightened over the course of three months, eventually glowing at about the brightness of the stars in the Big Dipper. When I was at Las Campanas in May, the supernova punctuated the soft glow of the Large Magellanic Cloud with its sharp crimson exclamation. In June and July the brightness faded rapidly, then settled into a smooth, slow decline, decreasing by half every 11 weeks.

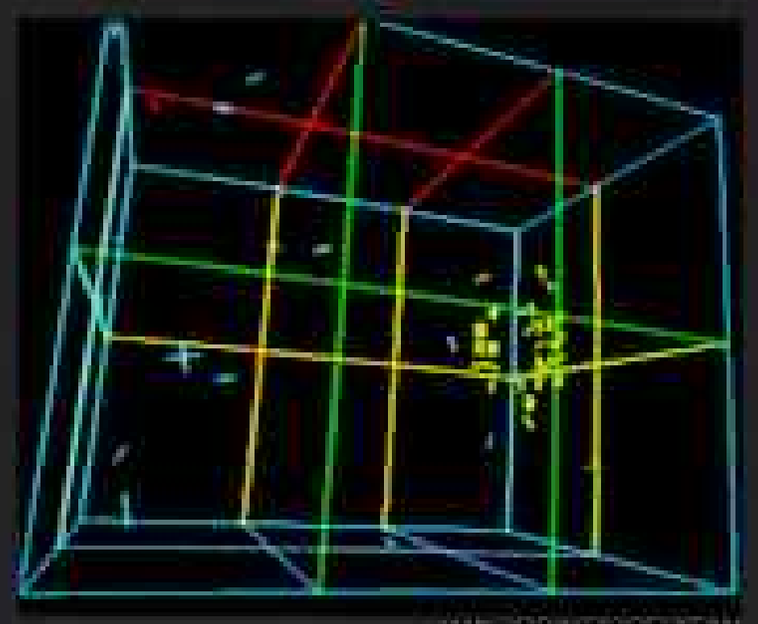
This clear pattern of decline strongly supported the theory that the sustained energy from a supernova comes from radioactive elements. The rate of decline and the amount of energy coming out corresponded exactly to the nickel-cobalt-iron decay pattern that theorists predicted from the nuclear physics of the explosion. "I'll stake my life," asserted Stan Woosley, "that there are 0.07 solar masses of cobalt inside her."

As the supernova expanded, it became more and more transparent, until it resembled a gas cloud more than a star. This stage brought into our view the light from inside the star, where heavy elements were synthesized during the star's evolution and forged in its explosion.

These measurements are made most easily in the infrared wavelengths. To facilitate the process, an observatory is lofted above the water vapor in earth's atmosphere. Data from NASA's C-141 Kuiper Airborne Observatory, flying a telescope at 41,000 feet, showed emissions from warm nickel, cobalt, and iron glowing deep in the heart of the supernova debris. That glow, we calculated, was probably heated by the radioactive cobalt as it decays with a half-life of 77 days.

From the iron heart of the destroyed star the radioactive debris emits powerful gamma rays as the nuclei change from nickel to cobalt to iron. These high-energy photons bounce off

AWAITING IDEAL CONDITIONS, a technician dozes by a spool used to launch a balloon from Alice Springs in Australia's Northern Territory. The payload on the NASA launch crane (opposite) is Caltech's Gamma Ray Imaging Payload, which found evidence of radioactive cobalt 56.



IMB COLLABORATION

First messengers of the star's death throes were trapped 2,000 feet beneath Lake Erie in a pitch-dark tank of water lined with 2,048 light sensors, here inspected by a diver. Operated by the University of California at Irvine, the University of Michigan, and Brookhaven National Laboratory, the detector confirmed that supernovae release a flood of particles called neutrinos. Perhaps 100 billion per square inch struck the earth—and exactly eight of them were detected when they interacted with protons and electrons in the tank's water on February 23. A computer simulates one resulting flash of light (above).

JOE STANCAMPIANO, NGS STAFF, AND KARL LUTTRELL, UNIVERSITY OF MICHIGAN

the atoms in the expanding stellar shards and lose their energy in heating the overlying gas. The optical light reflects the radioactive behavior of the cobalt heat source.

The most direct way to seek out radioactive elements is to look for the high-energy photons they emit. In August 1987 at an astronomy meeting in Tokyo, much of the discussion centered on when we might detect high-energy gamma or X rays from SN 1987A. Two speakers predicted that these photons would begin to leak out around November, showing up as X rays. Then Yasuo Tanaka of Japan's Institute of Space and Astronautical Science startled everyone by reporting a new source of X rays at the same place as the supernova. They had been observed since July by the institute's X-ray satellite Ginga.

Tanaka was reluctant to say that the emissions were from SN 1987A, but the Soviet space station Mir also detected the high-energy X rays. And the pattern of energy received reveals that the X rays begin as gamma rays from cobalt decay, reinforcing the theoretical calculations.

The circumstantial evidence for radioactive materials was growing—the steady optical light decline, the warm iron seen in the infrared, and the degraded gamma rays detected by the X-ray satellites.

But direct observation was needed. Gamma rays from cobalt were long ago measured in laboratories on earth. Seeing photons with those exact energies from SN 1987A would be conclusive evidence that the supernova produced these radioactive elements.

Now we seem to have it.

Last December investigators using the gamma-ray detectors on NASA's Solar Maximum Mission satellite (the one repaired in orbit by shuttle astronauts in 1984) and two groups using gamma-ray detectors carried 125,000 feet up by balloons all reported seeing evidence of the predicted cobalt emission. Just as the neutrino detection moved the core-collapse picture from myth to reality, this gamma-ray detection nailed down the production of radioactive elements in supernova explosions.

THE SN 1987A STORY is not entirely a tale of mysteries solved and of advanced technology confirming brilliant theory. Where is the neutron star? And what is the so-called Mystery Spot?

The elusive neutron star raises intriguing questions. According to theory, one should be there. The neutrino signal—those 19 neutrinos in the water tanks—agrees with theory and indicates that the supernova should have yielded such a star. But we have not yet seen it.

There is more evidence for a neutron star. The Crab Nebula, the remnant of a supernova explosion in our own galaxy seen in 1054, has a spinning neutron star, as does a supernova remnant in the Large Magellanic Cloud. But these do not prove that *every* supernova produces a neutron star.

Possibly the core of the Sanduleak star was so massive that gravity won the final battle, shrinking the core beyond a neutron star into a

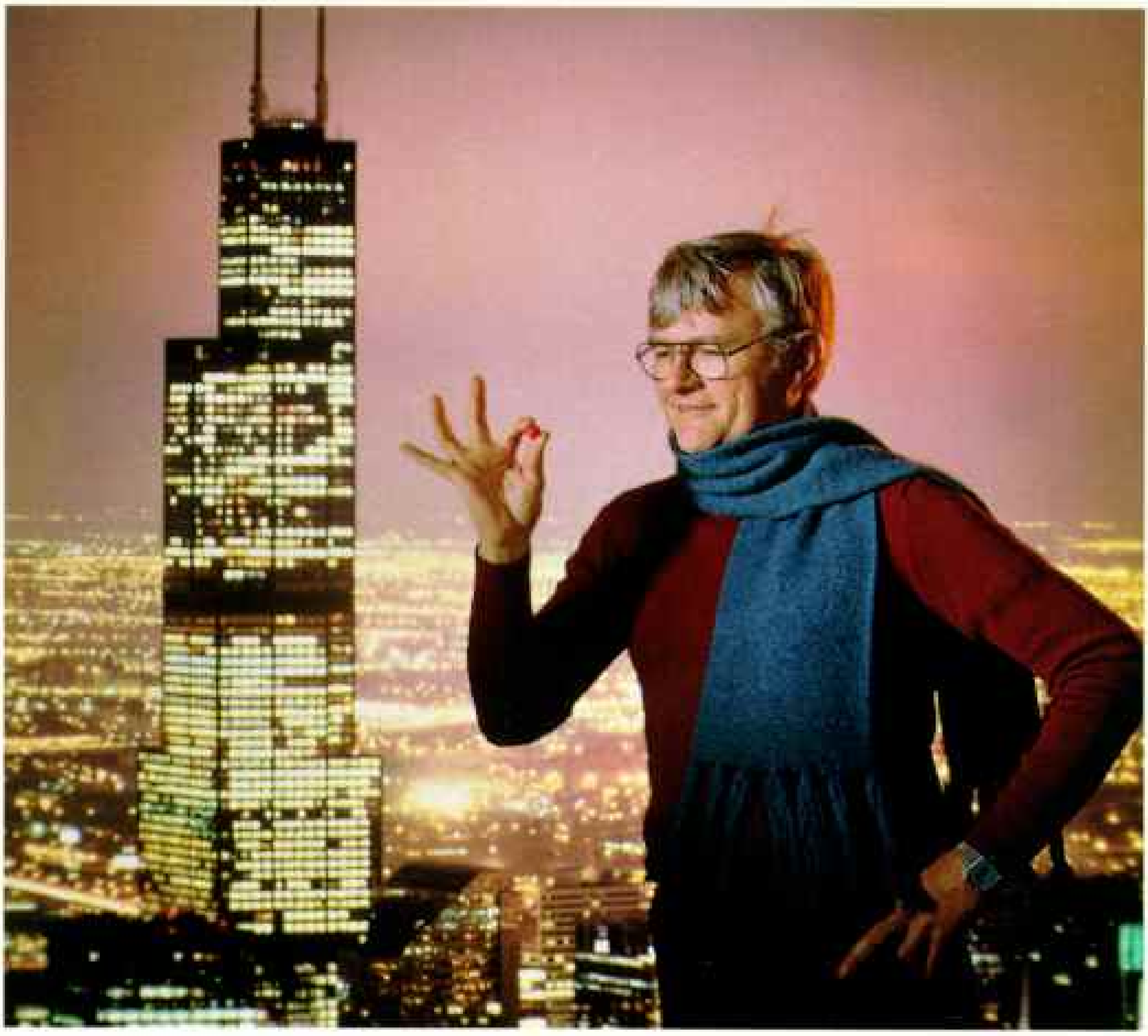
black hole, a region of space and time from which matter and light cannot escape. There are probably black holes orbiting stars that we see, including the bright X-ray source LMC X-1 near SN 1987A. And black holes are unlikely to have formed in a quiet way. Perhaps some supernovae lead down that path.

We cannot yet simply look and see if SN 1987A has a neutron star; detritus from the explosion still obscures its center. When the veils are dropped, we may see the hot surface of the neutron star glowing in X rays, or a region where high-energy particles have been accelerated by a spinning, magnetic neutron star, or perhaps pulsing X-ray and optical emissions from the neutron star.

And then, the Mystery Spot.

Costas Papaliolios and his colleagues at the Harvard-Smithsonian Center are able to measure astronomical objects in ways that cleverly elude the blurring effects of the earth's atmosphere. Shortly after the supernova was discovered, Cos and his co-worker Peter Nisenson proceeded to Chile to use the four-meter telescope at Cerro Tololo for high-resolution imaging.

Their results were astonishing. In April 1987 they found that the supernova, which appears as a single star in other observations, had a new small companion, quickly labeled the Mystery Spot. It couldn't have been there before the supernova occurred because it



WHAT IF the Sears Tower behind University of Chicago professor Dave Arnett were solid rock compressed to the density of a neutron star? It would be the size of the half-inch ball he holds —and would weigh some ten billion pounds. George Sonneborn, who studies data from the International Ultraviolet Explorer (IUE) satellite, stands behind author Kirshner, a Harvard astrophysicist, as they examine the first IUE supernova data (opposite, top). Stan Woosley uses a supercomputer at Lawrence Livermore National Laboratory to build supernova models.

would have been the brightest object in the LMC. Yet if it was ejected from the supernova and had moved so far away, it must have traveled at a minimum of half the speed of light—quite an unusual event.

Are the data establishing the spot convincing? An independent measurement by an Imperial College, London, group on the four-meter Anglo-Australian Telescope gave a similar result. But subsequent observations by both groups have not shown the spot, so it remains indeed a mystery.

FINALLY WE TURN to the nagging question of why the Sanduleak star was blue when it blew. Or was it red before it was blue? As I mentioned, indirect evidence indicates that most Type II supernovae are red supergiants when they explode.

A possible pedigree for the star is suggested by the University of Chicago's Dave Arnett. In the LMC fewer supernovae have occurred than in the Milky Way, and thus the accumulated reserves of heavy elements are lower. Arnett's calculations show that stars may be blue all their lives under these conditions, evolving from hydrogen-burning youths to a brief blast of silicon burning.

But evidence is accumulating for another possibility—that the Sanduleak star was for a time a red supergiant.

These supergiants give off substantial stellar winds in which several solar masses may be gently exhaled. These losses could have slimmed the star from a red supergiant to a smaller blue one. Did the Sanduleak star have a phase like this? Recent evidence from the IUE satellite points clearly in that direction—

OUR OWN STAR glitters at sunset over the European Southern Observatory mountaintop complex in Chile. Lingering supernova emissions will occupy generations of investigators in a fascinating postmortem.

narrow emission lines that have the composition of a red supergiant wind. A plausible picture shows a dense shell of matter around the supernova, lost from the star about 30,000 years ago and now excited by the ultraviolet light from the supernova explosion.

The fast-moving debris of the explosion will eventually collide with this dense shell. If the shell is at a distance of one light-year and the debris is moving at one-tenth the speed of light, then it will be ten years until this violent collision occurs. We can expect a brilliant recrudescence of SN 1987A, especially in X rays and radio emissions, to celebrate the end of the century.

Future observations will center on the search for a small, hot neutron star and on refining our measurements of the chemical abundances inside the exploded star. Our eyes will be sharpened when NASA's shuttle launches the Hubble Space Telescope, which will have unparalleled imaging ability, and eventually by NASA's AXAF (Advanced X-ray Astrophysics Facility) satellite, which will permit X-ray analysis of the hot gas and the search for a neutron star.

Overall, SN 1987A has been an ideal laboratory for learning about supernovae: surprising but understandable. I had always hoped for a bright supernova in my lifetime. I am beginning to realize that studying this one will last a lifetime. □

The Persian Gulf

Living in Harm's Way

By THOMAS J. ABERCROMBIE
NATIONAL GEOGRAPHIC SENIOR WRITER

Photographs by STEVE RAYMER
NATIONAL GEOGRAPHIC PHOTOGRAPHER

THROUGH THE COOL DAWN, brief respite between night's starry blackness and the scorching day, we headed across the turquoise waters of the Persian Gulf. From the fleet of bobbing dhows turbaned fishermen, piling nets and wire traps, paused to wave their salaams. Behind us, streaming down from the jagged cliffs that walled the oasis, the sun's first rays pierced the dusty palm groves to light the Arabian Nights fortress that guards the bay.

In bright paisley headcloth and long blue caftan, his dark eyes sparkling above a thick black mustache, our barefoot captain could have passed for Sindbad himself, except. . . . He glanced at the chartreuse sweep of his radarscope, then eased throttles forward to eight knots and set his boxy 120-ton tanker on a course of 030°, out into the Strait of Hormuz.

The *Khasab*—named for its home port, the capital of Musandam province, Oman's northern outpost on the strait—is one of three landing craft converted by the Musandam Development Committee to ferry drinking water to thirsty villages along the hidden inlets of the rocky peninsula.

"We stay well inside the heavy steamer traffic," said Capt. Saif Ahmad Saif al-Shahi, a 15-year gulf veteran. As the mate poured us cardamom-spiced coffee from a thermos, I counted on the horizon five giant tankers steaming a parallel course northeastward 12 miles out. Closer in, a lateen sail marked a large wooden dhow plodding south.

"From Karachi or Bombay," the captain concluded, scanning it with binoculars. "Gulf dhows nowadays are all motor powered."

We threaded the *khawr*, or inlet, between the mainland and Oman's Goat Island Naval Base. From here radar and patrol boats armed with French Exocet missiles monitor the 24-mile gap between the Arabian Peninsula and Iran. Each day dozens of supertankers steam through this funnel to the strategic Persian Gulf basin, source of half the world's oil. When Baghdad spread the Iran-Iraq war into the gulf with attacks on Iran's oil ports, Iran threatened to choke the strait.

"The Persian Gulf will be safe for all—or nobody," Iran's speaker of parliament, Hashemi Rafsanjani, had warned.

The United States and other nations deployed naval escorts and minesweepers to protect shipping—but by late last year air raids and gunboats were hitting an average of a ship a day in these waters.

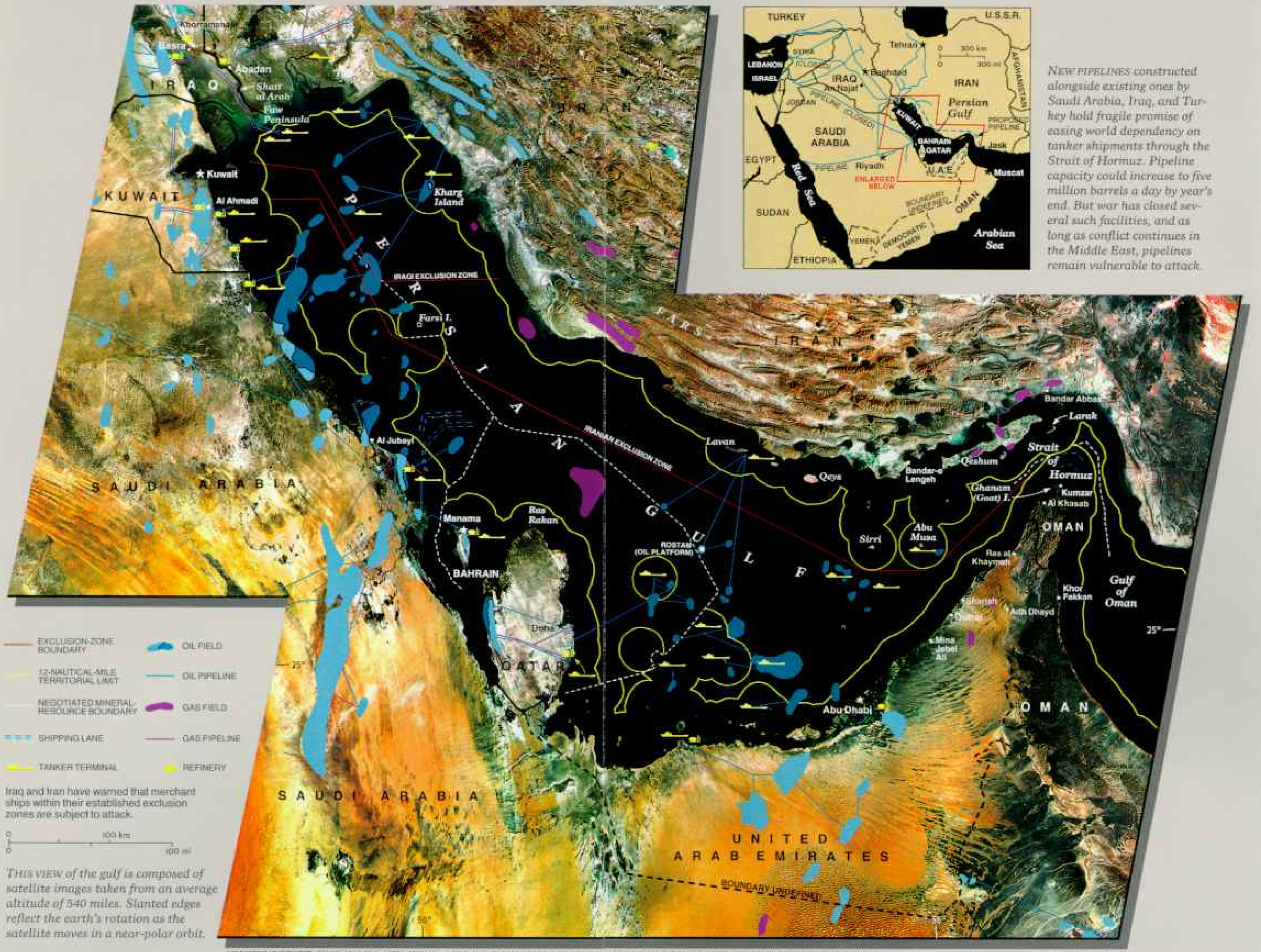
"Insurance rates have skyrocketed since the tanker war heated up last fall," Capt. John Wallwork told me, just down the coast in Sharjah. The tall Lancashireman runs a flotilla of supply ships through the lower gulf's dangerous Silkworm Alley for InterMarine, a Texas-based company. "Surcharges can reach a thousand dollars a day for a large tanker. North of 27° latitude our crews now draw double pay.

"Iraqi planes hit our *Big Orange XIV* near the Ras al Mutaf lightship, killing the captain and one crewman," he said, pointing out the site on a wall-size blue-and-yellow sea chart. On it he had inked *(Continued on page 656)*

DOOMED by attack from Iranian gunboats last December, the Singaporean tanker Norman Atlantic burns after loading in Kuwait. Omani coastguardsmen rescued the crew, but the Japan-bound ship exploded and sank, as tensions intensified in the Persian Gulf.

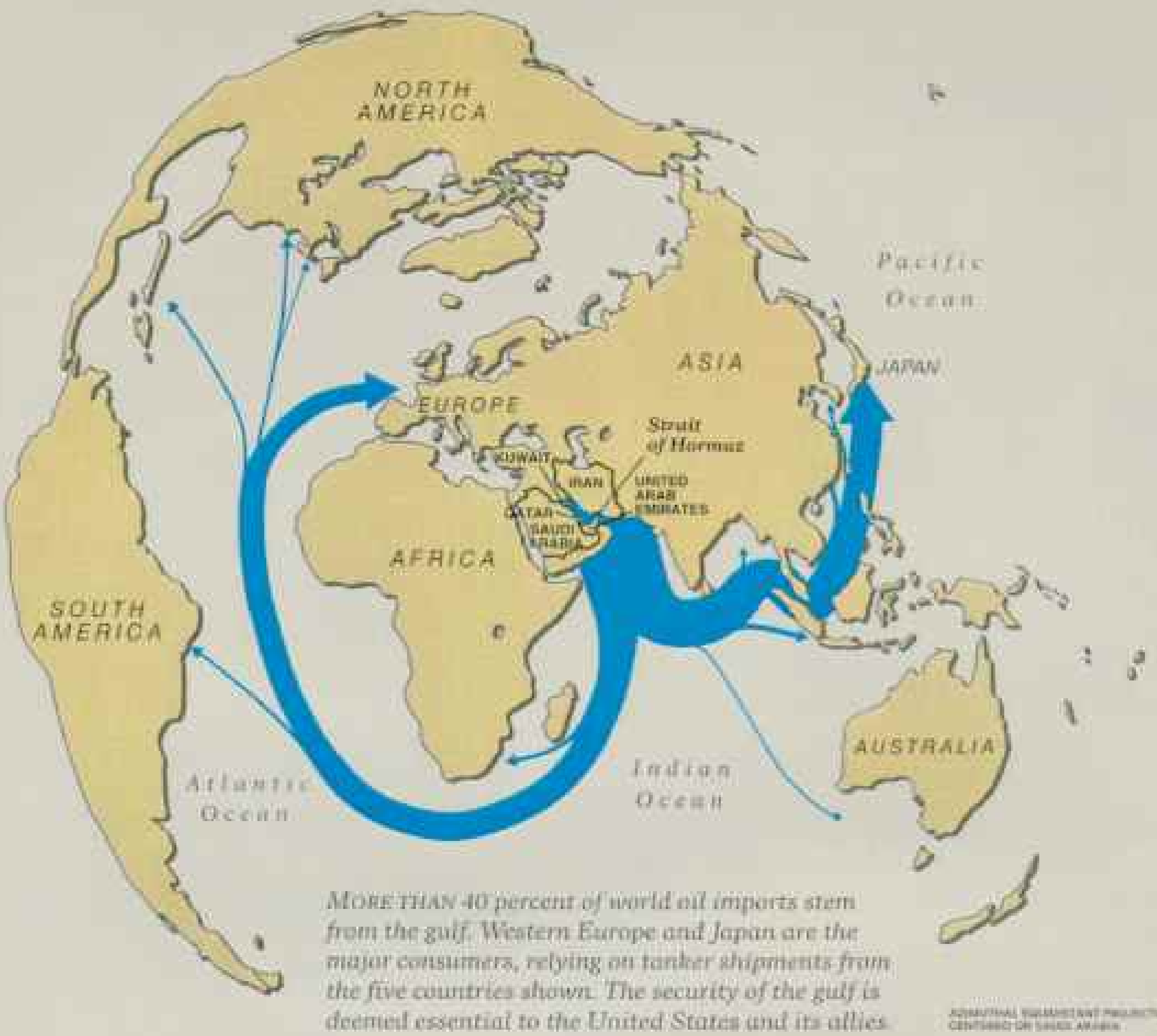
FABRICE MOUSSEAU, ABC NEWS

NEW PIPELINES constructed alongside existing ones by Saudi Arabia, Iraq, and Turkey hold fragile promise of easing world dependency on tanker shipments through the Strait of Hormuz. Pipeline capacity could increase to five million barrels a day by year's end. But war has closed several such facilities, and as long as conflict continues in the Middle East, pipelines remain vulnerable to attack.



THIS VIEW of the gulf is composed of satellite images taken from an average altitude of 540 miles. Slanted edges reflect the earth's rotation as the satellite moves in a near-polar orbit.

NGS CARTOGRAPHIC DIVISION: WILLIAM CHARLES M. SCOTT, RESEARCH; MARK P. ANDLER, MARGARET K. MCBRIDE, PRODUCTION; RICHARD W. BALDWIN, VICKI A. MCMAHON, MAP EDITOR; JOHN T. BLOZIS



MORE THAN 40 percent of world oil imports stem from the gulf. Western Europe and Japan are the major consumers, relying on tanker shipments from the five countries shown. The security of the gulf is deemed essential to the United States and its allies.

ADAPTATION: NATIONAL GEOGRAPHIC MAP PRODUCTION CENTERED ON SAUDI ARABIA

Geopolitics of oil

PETROLEUM, religious fervor, and tangled international relations have made a deadly brew in the Persian Gulf. A web of often disputed boundaries overlies the water (foldout, left).

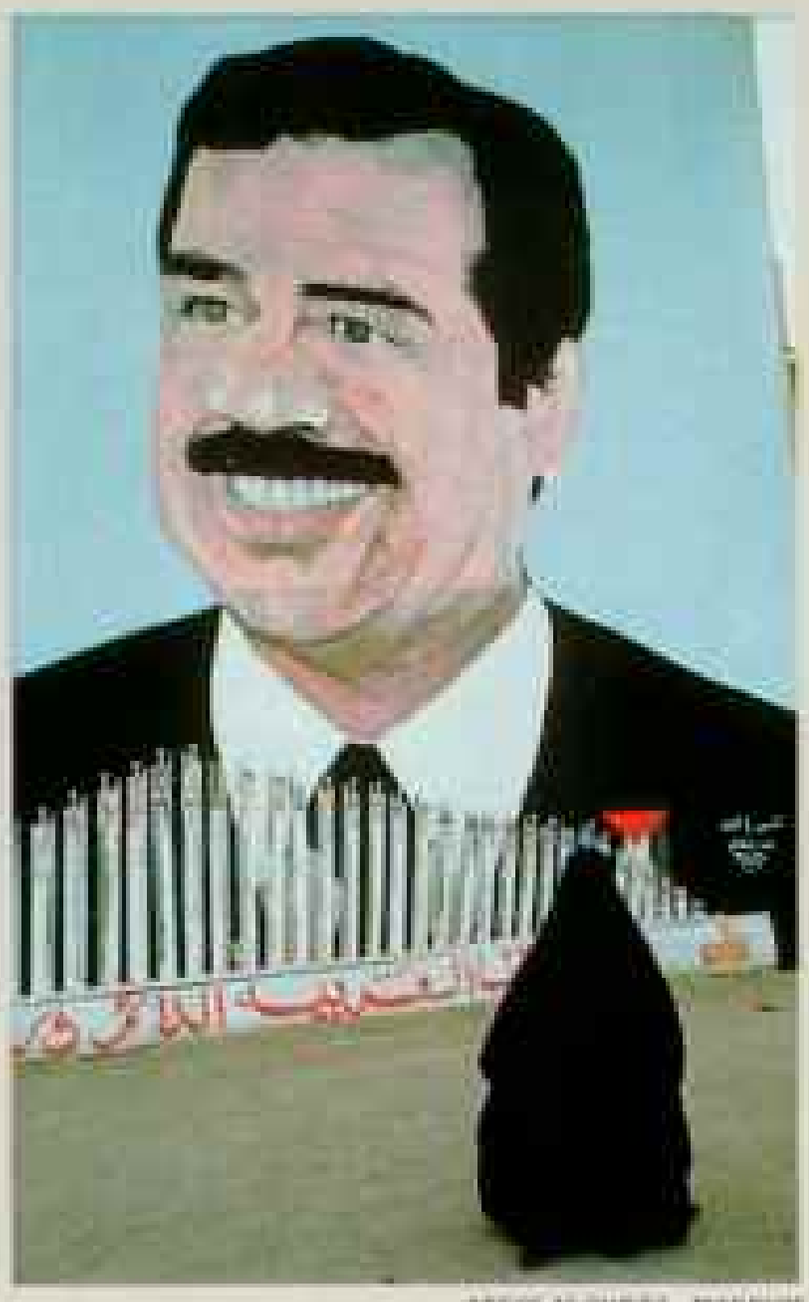
Two-thirds of the oil exported by gulf countries passes through the narrow Strait of Hormuz. Pipelines carry most of the remainder to ports on the Mediterranean and Red Seas (inset). Closing the strait, which Iran has threatened, would erode the world's current oil surplus, increasing prices—and international tensions.

Another strategic waterway lies 550 miles away at the head of the gulf. There the Tigris and Euphrates Rivers empty into the 120-mile-long Shatt al Arab, subject of a long-standing border dispute between Iran and Iraq, antagonists with deep-seated differences.

The Arab nation of Iraq has been controlled by the socialist Baath Party since a coup in 1968. The population includes members of Islam's two major branches: 35 percent are Sunnis and 63 percent Shiites. Sunnis, about 85 percent of the world's Muslims, hold that after the death of Muhammad leadership passed to caliphs elected from the Prophet's tribe. Shiites, the largest minority, believe that religious authority is invested only in descendants of Muhammad's son-in-law, Ali, who is buried in An Najaf, Iraq.

Most Iranians are not Arabs, but Indo-Europeans who speak the Persian language. In 1979 religious fanaticism washed over Iran, which is overwhelmingly Shiite. Shah Mohammad Reza Pahlavi was ousted, and the new religious leadership installed Islamic law. The war began when Iraq invaded its troubled neighbor in September 1980, striking refineries and an oil-loading terminal on Kharg Island. Iran responded in October by taking Iraq's gulf oil terminals and preventing Iraqi tanker shipments through the gulf.

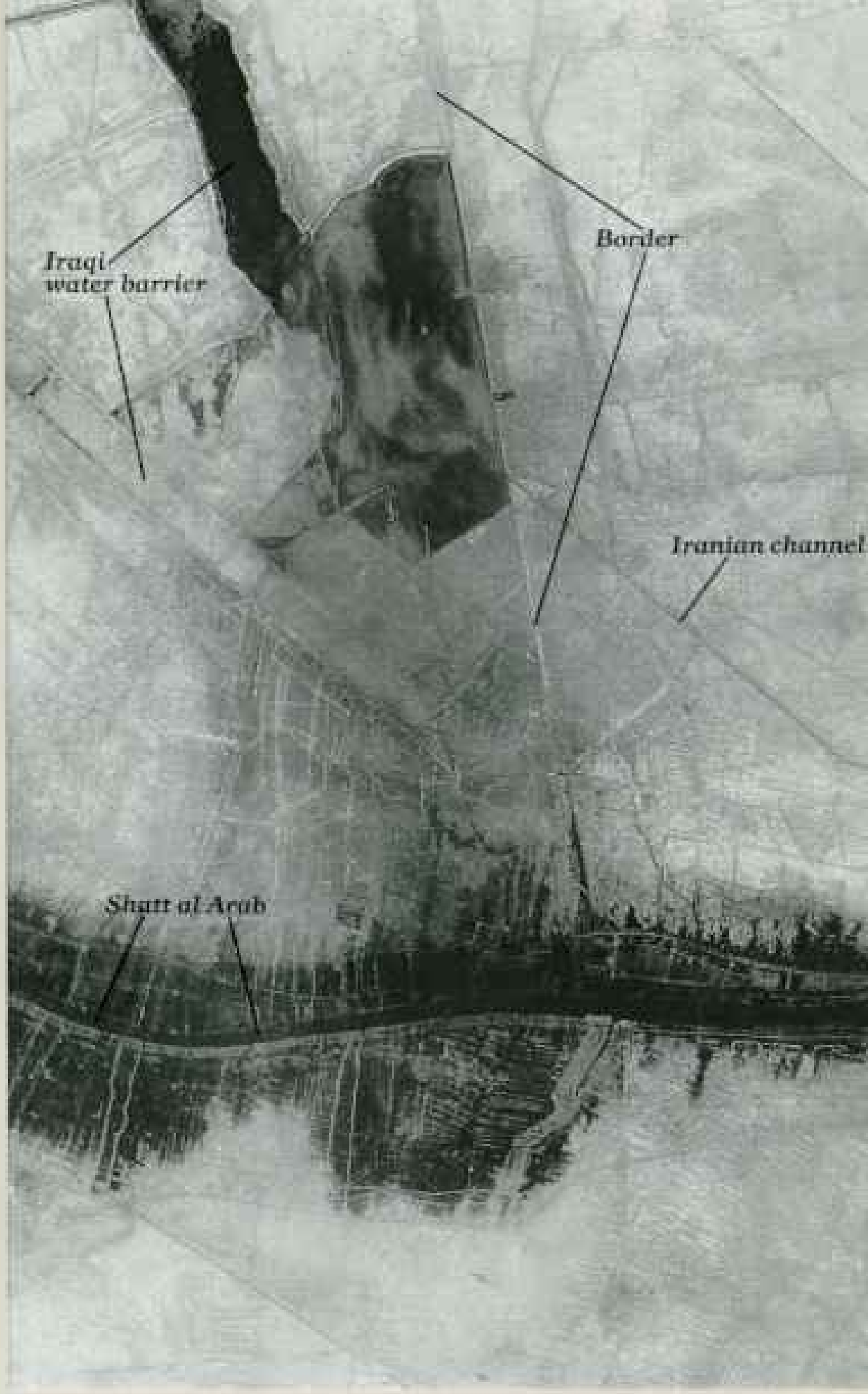
The U. S. was jolted in May 1987, when an Iraqi jet accidentally fired upon the frigate U. S. S. *Stark* in the gulf, killing 37 crewmen. In July the U. S. began escorting Kuwaiti oil tankers sailing under the U. S. flag. Though the causes of the war are deeply embedded in religion, nationalism, and economics, the United Nations and others continue attempts to negotiate a settlement.



STEVE MCCURRY, MAGNUM

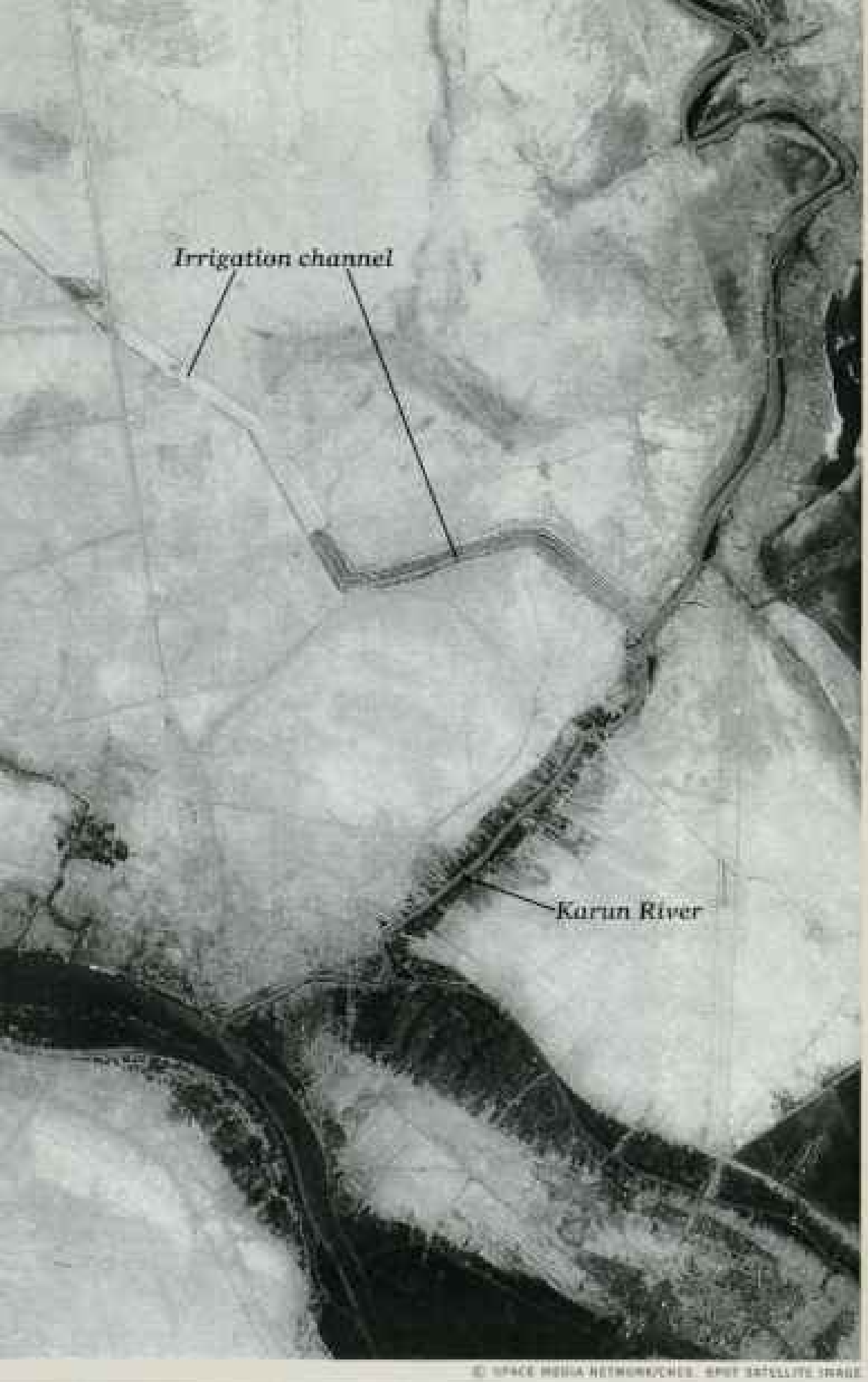
GIANT PORTRAIT of Iraqi President Saddam Hussein overlooks a Baghdad street. An inscription lauds "Arab forces" in his nation's struggle with its non-Arab enemy neighbor, Iran.

As a tactical device, Iraq created a water barrier (right) by pumping water through channels from the Shatt al Arab. The barrier serves as a means of protecting Basra—Iraq's second largest city—by forcing the invading Iranians into constricted theaters of operations north and south of the barrier.



Uneasy neighbors of an unrelenting war

LIKE A QUARRELING FAMILY, gulf countries are both united and divided by their Islamic heritage and mineral riches. Within a year of the Iraqi invasion, Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates, and Oman established the Gulf Cooperation Council to strengthen economic and cultural ties. Security has been foremost on the agenda.



© SPACE IMAGING NETHERLANDS. EROS SATELLITE IMAGE

KHAMENEI BARRIOS, SYGMA

STERN GAZE of Iran's Ayatollah Ruhollah Khomeini peers from a mural behind women attending the departure of Revolutionary Guards for the battlefront last September. Khomeini, with his zealous view of Islam, regards Saddam Hussein as both an enemy and an infidel.

In its tactical use of water, Iran resorted to flooding the area surrounding the Karun River to stop Iraqi tank movements and has begun digging its own channel, apparently in an effort to drain Iraq's water barrier.

Iraq *Socialist republic; 63% Shiite, 35% Sunni.* AREA: *167,925 sq mi.* POPULATION: *17 million.* PER CAPITA INCOME: *$2,140.* ESTIMATED OIL RESERVES: *100 billion barrels.*

Iran *Islamic republic; 93% Shiite.* AREA: *636,343 sq mi.* POPULATION: *50.4 million.* PCI: *$1,690.* RESERVES: *93 billion bbls.*

Kuwait *Monarchy; 45% Sunni, 30% Shiite.* AREA: *6,881 sq mi.* POP: *1.9 million.* PCI: *$11,510.* RESERVES: *92 billion bbls.*

Saudi Arabia *Monarchy; 85% Sunni.* AREA: *830,060 sq mi.* POP: *14.9 million.* PCI: *$8,850.* RESERVES: *172 billion bbls.*

Bahrain *Emirate; 70% Shiite, 30% Sunni.* AREA: *239 sq mi.* POP: *464,000.* PCI: *$9,600.* RESERVES: *141 million bbls.*

Qatar *Emirate; 68% Sunni.* AREA: *4,247 sq mi.* POP: *316,000.* PCI: *$22,000.* RESERVES: *3.1 million bbls.*

U.A.E. *Federation; 80% Sunni, 16% Shiite.* AREA: *32,280 sq mi.* POP: *1.8 million.* PCI: *$19,270.* RESERVES: *99 billion bbls.*

Oman *Sultanate; 75% Ibadhi Muslim.* AREA: *82,037 sq mi.* POP: *1.2 million.* PCI: *$7,800.* RESERVES: *4 billion bbls.*

(Continued from page 648) a maze of exclusion zones, attack sites, and minefields.

"There are 500 ships in the gulf at any given time," Wallwork said, "besides some 2,000 men actually living out on the water, on the offshore oil platforms and drill rigs that dot the gulf. Our job is to keep them supplied with food, water, machinery, spares, drill pipe. We live with the risks, try to minimize them."

Joining newsmen in a French-built turbo helicopter flying out of Ras al Khaymah, I brushed with warships from seven different nations in a single day: U. S., Soviet, Italian, French, Omani, British, and Iranian. Using the pilot's radio and my own hand-held VHF tuned to the channel-16 ship frequency, we got permission to overhaul a Soviet *Sovremenny* class destroyer steaming just inside Hormuz Strait, and the Soviet seamen sunbathing on the afterdeck paid us no mind. Italian minesweepers, anchored among damaged supertankers off Dubai, radioed us an invitation to land on deck for a visit.

Although our rendezvous with the U. S. Navy helicopter carrier *Guadalcanal* had been arranged by telex before our takeoff, we received a cautious reception from that floating hornet's nest. As we hovered a thousand feet above the water, a helicopter gunship suddenly appeared alongside, startling my pilot. The U. S. Marine Corps crewmen looked us over sternly from what seemed an arm's length away, then, in a blink, they were gone, and

PLAYING A DANGEROUS GAME of follow the leader, the helicopter carrier U.S.S. Guadalcanal sails with a convoy of reflagged Kuwaiti tankers and other U. S. warships. On watch aboard the McClusky, Gunner's Mate Cruz Felix shoulders a Stinger missile.

the ship radioed us permission to photograph.

Tension is high in this no-rules war where a floating dead sheep can spark a mine scare and small speedboats sink giant tankers. For the sailors a six-month tour becomes an eternity. Chief Petty Officer Gary Gilliam of Sanford, North Carolina, probably summed up the feelings of his shipmates about the whole experience when he said, after attending a USO show, "Given a choice, I'd rather be home watching this on TV."

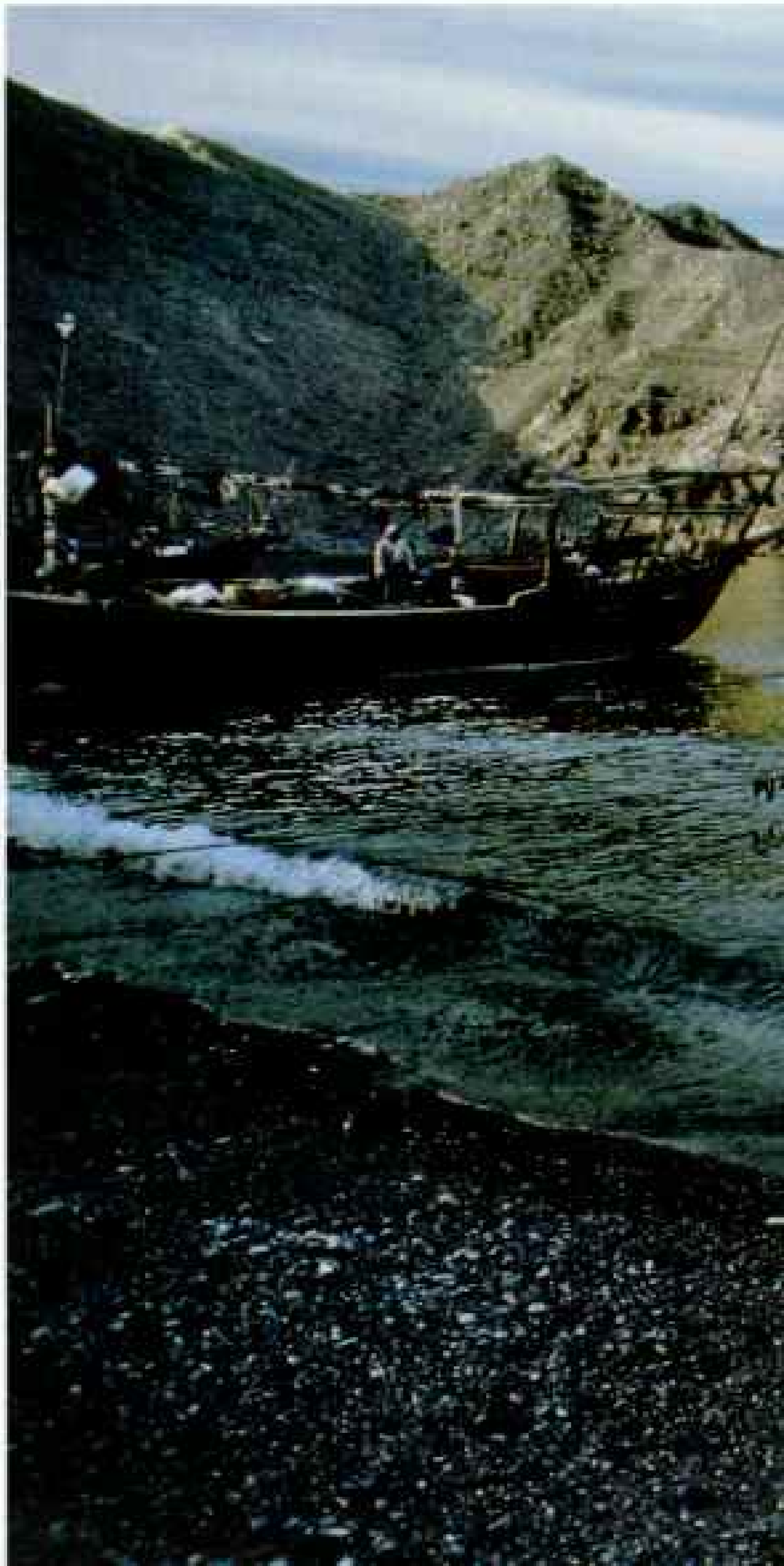
"Helicopter! Helicopter! This is Iranian warship! Identify yourself! Repeat, identify yourself!" my radio crackled as we approached a bristling silhouette farther north.

Quickly we radioed our call numbers—and peaceful intent.

"Helicopter Sierra Lima Bravo, you are in a war zone! Leave the area immediately!" barked the order. Then as we banked away, "Thank you for your cooperation."

I HAD A FRONT-ROW SEAT on the conflict during recent visits to the amphitheater of desert states—Kuwait, Saudi Arabia, Bahrain, Qatar, the United Arab Emirates, and Oman—that bound the gulf's southwestern shore. I met Omani sailors and fishermen, Friday crowds in the mosques at Abu Dhabi, big-buck currency traders in Bahrain's offshore banks, taxi drivers simmering in Dubai's downtown traffic, veiled harems cruising Kuwait's chic shopping malls, bikini-clad expatriates at a seaside Hilton club, and beard-stroking bargainers in a redolent camel bazaar. For most of them, life goes on. The war lies over the horizon.

Gulf Air, on the other hand, flies right



Oman *An aged hand and traditional* birkah *veil a Shihuh woman caring for her grandson on Oman's rugged Musandam Peninsula while the boy's father works in Abu Dhabi. Oil-related jobs are eroding the isolation of the reclusive Shihuh, a process furthered here by a school, a hospital, and electricity. Boats arriving at the Musandam village of Kumzar (right) bring radios, TVs, and cases of soft drinks.*

through it. Westward from Oman we climbed out over the troubled waters near Sharjah and headed through a crystal sky down the middle of the gulf. The window of my 737 unrolled, from 31,000 feet, a map-perfect panorama of Iran's desert coastline and the gray-streaked Fars mountains beyond. The small islands of Sirri, Qeys, and Abu Musa slipped by below, speedboat bases for Iran's militant Revolutionary Guards, who attack tankers with rockets and rifle grenades. From the window across the aisle I saw the white arrowhead wakes marking a pair of U. S. Navy frigates steaming northeast off the Arabian coast.

"The superpowers should fight their battles elsewhere," my fellow passenger declared, an elderly businessman in the Arab white robe and headcloth. "If the fighting spreads, our small countries will suffer the most."

I backed off—it was his window I was monopolizing—but reminded him that the whole industrialized world counts on energy from the gulf, especially Europe and Japan. Containing the conflict was the aim of the visiting navies. And, in fact, it was Kuwait's tankers that were under convoy.

Lunch trays interrupted our debate. Flying through smoke rising from Iran's Rostam oil platform below—shelled by U. S. ships the week before—we ate our *salade vinaigrette*, *filet de grouper*, and *petits fours* in silence.

Given today's politics, even the name of the gulf can start an argument. Most cartographers label it "Persian Gulf," a precedent dating from at least as far back as the second-century maps of Ptolemy; Arab nations on the western shore insist on "Arabian Gulf." Today more and more publishers avoid ideology

and steer a neutral course down "the Gulf."

Our flight skirted Ras Rakan, Qatar's outer tip, and the once rich pearl-oyster beds north of Bahrain before crossing the coast over Saudi Arabia's new eight-billion-dollar industrial port city, Al Jubayl. Then we veered inland a hundred miles—fighter planes and warships often warn airlines away from the shore—before gliding back along a web of pipelines toward the glittering skyline of Kuwait city.

My Palestinian taxi driver, a longtime resident of Kuwait, gave me a narrated quick tour along the expressways that ring and spoke the city, accompanied on his dashboard cassette by the velvet melodies of sliding quarter notes in minor keys of Abdel-Karim Abdel Qadr—Kuwait's John Denver:

Though your love costs me dearly,
Allah salute you,
Be my soul forever.

We sped past Kuwait's water towers, enormous spiked bulbs, one housing a restaurant 400 feet above the seashore ("Fine buffet but very expensive"); the parliament building, a giant concrete tent by the architect who created the Sydney Opera House ("We have a democratic constitution, but the emir—he is still powerful—dissolved the assembly last year, for the second time"); the ice-skating rink ("We have two; this one is Olympic size"); Shuwaikh port ("Home port to the largest Arab merchant fleet"); lavish residences like Marzuk palace ("Just one man lives here—and 35 servants"); the 15-story television building ("Color channels in both Arabic and English, and we pick up Iran, Iraq, and Saudi Arabia as well").

Despite the war, a stock-market crash in 1982, and a world glut that has cut oil income by half, Kuwait's per capita income, $12,000, ranks it among the world's richest nations. Medical care and university education are free, and housing, water, and electricity heavily subsidized. Kuwait's Finance Ministry invests a percentage of its oil revenue in enterprises around the world, such as Daimler-Benz and Hoechst Chemicals in Germany. It owns outright Kiawah Island Resort in South Carolina and the 2.5-billion-dollar Santa Fe Corporation. "Our investments will be the main source of income for generations after the oil runs out," explained an economist at the Finance Ministry.

Kuwait's massive growth called for foreign labor and expertise. Hundreds of thousands came to build the country and share in its prosperity: from England came government advisers and management; from Pakistan, Yemen, and Korea, laborers; from India and Iran, clerks and shopkeepers. Egypt and the Palestinian diaspora provided teachers, doctors, lawyers, engineers. Today Kuwaitis find themselves a minority in their own country—about 40 percent—as do populations in Dubai and Abu Dhabi. In Qatar, chances are,

Kuwait *With a taste for racy cars, shoppers in Kuwait city inspect a Corvette at a daily auto auction. Kuwait enjoys one of the world's highest standards of living. Medical care and university education are free to citizens, and housing, utilities, and telephone service are subsidized. The government pays more than $7,000 to every couple upon their marriage.*

Yet oil has made Kuwaitis a minority in their own land. Foreigners now outnumber natives three to two, straining water supplies and other resources. In Kuwait city a mammoth oil tanker looms beyond the field where Japanese employees of Mitsubishi Heavy Industries play baseball.

Bahrain *Worry beads click in the hectic currency and securities trading room of Gulf International Bank in Manama, a city of 122,000 with some 170 financial institutions. At Arabian Gulf University a physician and medical students discuss treatment for a girl with rheumatic fever.*

only one of four people you meet is a native.

"What haunts the immigrant here is the future," a Jordanian friend said, "actually the *lack* of one. My son was born here but will never be a citizen. An uncle worked a lifetime in Kuwait. When he retired, they gave him a week to leave the country."

Only 40 miles from the battlefield and an outspoken ally of Iraq, Kuwait alone among the small gulf states has suffered Iranian attacks on her shores. Not surprisingly, it took several days to arrange a brief—and heavily guarded—visit to the Kuwait Oil Company's refinery in Al Ahmadi. KOC spokesman Raad al-Jandal apologized for the formalities.

"These are difficult times. Our installations have been hit by Iranian missiles," he said. "Last summer some of our own workers sabotaged the refinery. Fire trucks and helicopters battled 15 days to put out the blaze."

On a Friday visit to the beach, photographer Steve Raymer's cameras raised immediate alarm. Blue-uniformed officers hustled us off in a squad car for a tire-screeching race to the police station. They had snared, I gleaned from their excited exchange, two master spies.

"You must carry written government permission to photograph in Kuwait," the unsmiling counterintelligence inspector told us during his interrogation. Our ministry sponsor finally arranged release and, by late evening, a reunion with our cameras and passports.

"Each of the Arab gulf states has a personality of its own, yet all are heir to the same desert clime, the same language and religion. They share a common history of tribal politics," Kuwaiti editor Mohammed Rumaihi told me amid the elegance of glass, marble, and fine Persian carpets of his home in the heart of the city. Now in its 30th year, his monthly magazine, *Al-Arabi*, reaches more than a quarter of a million subscribers.

"In 1981," he continued, "the small gulf states formalized their common bond to create, with Saudi Arabia, the Gulf Cooperation Council. It has already developed gulf-wide programs in education, finance, and technology. Eventually we will see our own common market here, and a federal defense force. But that will take time.

"Lying near the junction of Europe, Asia, and Africa, the gulf has been a strategic waterway since the time of Babylon," Dr. Rumaihi said. "The world's first maps survive on the clay tablets of the Sumerians, who first navigated on it. As a focus of trade the gulf, long before the battle for oil, was a focus of conflict."

IN 1819, responding to attacks by Arab "pirate" ships, the British burned the port of Ras al Khaymah, then signed a truce with seven of the coastal Arab sheikhdoms. When the British pulled out in 1971, these Trucial States formed the United Arab Emirates. Qatar and Bahrain became independent countries, as Kuwait had in 1961.

The U. S., moving to fill the power vacuum, relied heavily on its "twin pillars" policy, selling arms to Iran and Saudi Arabia. Between 1972 and 1978 it poured 19.5 billion dollars' worth of weaponry into Iran alone, backing the largest peacetime military buildup of any country in history. But America's Iranian strategy centered on one man: the shah.

Ayatollah Khomeini's 1979 revolution, and the Tehran hostage crisis that followed, left American policy in a shambles. Desertions

and purges soon crippled Iran's military.

Seizing the chance to capture long-disputed territory, Iraqis attacked across the Shatt al Arab, trunk of the great Tigris-Euphrates river system, in 1980. But they underestimated the iron ayatollah. Although maimed by land mines and outgunned by Iraqi artillery, suicide waves of Iranian soldiers—many only boys—drove the invaders back, occupying Iraqi territory in turn and threatening Basra, Iraq's second largest city. The savage stalemate, now in its eighth year, has filled an estimated half million graves.

With its superior air force Iraq began pounding Iran's oil terminal at Kharg Island. With missiles, mines, and gunboats, Iran retaliated against the big ships carrying crude from Iraq's Arab allies.

Last summer President Reagan agreed to have the U. S. reflag and escort 11 Kuwaiti tankers through the 550-mile waterway. Britain, France, and Italy sent destroyers, an aircraft carrier, minesweepers. By October some 80 warships gathered in and around the gulf. The "tanker war" had begun in earnest.

WHEN THE ARAB GULF NATIONS decided to sponsor a regionwide Arabian Gulf University, Bahrain was the logical site for the campus. An established medical school in Manama, Bahrain's capital, offered temporary facilities for the new university. Centrally located along the gulf's western shore, and middle of the road politically and socially, the small island state had pioneered in education. Bahraini merchants opened the region's first modern school here in 1919.

"Since we opened our doors four years ago, enrollment has climbed to 350," said the university's president, Dr. Mahmoud Safar, a Saudi who completed degrees in engineering at Stanford. "We graduate the first class—from the medical school—in 1989."

AGU's energetic dean of medicine, Dr. Ali Matar, and I followed interns making their rounds at Salmaniya Medical Center. In the new classroom building next door we watched a brain dissection in the formaldehyde-laden atmosphere of the anatomy lab, then visited students mastering keyboards under banks of green computer screens.

Later we popped in on a pharmacology class—seven young women with their professor, an X-ray viewer, a projector for microscope slides, and a video player. The group resumed their animated discussion: what to do with a theoretical patient who was not responding to an antibiotic. The "patient" was treated to an international diagnosis. These

seven students represented five gulf states.

"We rely less on formal lectures than what we call tutorials," Dr. Matar explained. "Small classes, with plenty of give-and-take, based on exercises in problem solving."

In keeping with the university's charter, the curriculum reflects Arabic and Islamic values, especially the "cultural, scientific, and occupational needs of the contributing states."

Dr. Ahmed el-Agib outlined the Desert and Arid Zone Sciences Program he directs at AGU. "Historically as threatening to mankind as war is the deadly process of drought and desertification. It especially afflicts our region," he said.

"Now, for the first time, using the miracles of 20th-century technology—remote-sensing satellites, genetic engineering, solar power,

isotope hydrology—we can hold back, even reclaim, the desert. Our graduate program will train specialists to fight this battle."

BAHRAIN'S enlightened precincts have attracted a prosperous business and financial community. By the mid-eighties 170 or so banks, some fleeing war-shattered Beirut, had opened on the island.

One morning I visited the arabesque pink marble headquarters of Gulf International Bank along Manama's expensive waterfront.

Bachir Barbir worked four years for Chase Manhattan in Beirut before moving to Bahrain in 1976. Now one of Gulf International Bank's senior vice presidents, he supervises an international staff of 50 in GIB's trading room, one of the largest in the gulf.

"Gulf International is owned by seven gulf countries," explained Mr. Barbir, a dapper man, even in shirtsleeves. A smile animated his trim mustache, and he thumbed a string of rose-quartz worry beads. "We are a 'wholesale' bank; our customers are other banks and governments," he continued. "One of our functions is to serve as a link between the international finance market and our local currencies: dinars, riyals, and dirhams."

By 11 a.m. the pace of the trading room began to quicken. Halfway around the world the London market was just opening.

"Bahrain lies in just the right time zone for international trading," Barbir said. "That is why we work 12 hours a day, from 8 a.m. until 8 p.m., Bahrain time. Our day begins before the Tokyo and Singapore markets close, and we keep going, with an eye on London, until after New York opens."

I watched one chain-smoking veteran bidding on currency units at the long console he shared with two dozen other busy traders, a display that reminded me of NASA's Mission Control. Red and yellow lights flashed on seven telephones spaced around him, direct lines to the Far East and Europe. At his elbow a green screen glowed with the Dow-Jones quotations, while another monitor flashed color graphics of worldwide money trends in dollars, yen, and deutsche marks. A room-size recording system behind him kept track of it all. In the center of the now bustling room the financial screen unrolled an AP headline: IRAN MILITARY LEADER THREATENS ATTACK ON U. S. BASES IN PERSIAN GULF. Despite all the technology, transactions—tallied in "units"—were penciled on small paper squares.

Bahrain *Nearly nine acres of fresh paint refurbishes a Greek oil tanker of 357,000 tons deadweight undergoing a refit at the Arab Shipbuilding and Repair Yard. The dry dock also repairs war-damaged vessels.*

Dubai *Its shores once known as the Pirate Coast, Dubai—second most populous of the United Arab Emirates, after Abu Dhabi—prospers as a trading center. Goods from Asia and other nations are imported and reexported from Port Rashid's containerized-cargo*

terminal, foreground, and other facilities. Forty-nine airlines use the emirate's airport, which accommodates frequent flights from Iran. On the horizon, natural gas—an underutilized commodity in the gulf—is flared off from a field in neighboring Sharjah.

". . . 44? . . . 45? . . . 46! OK, I'll take three units at 1.646," the dealer bargained.

As the chits piled higher, the dealer's ashtray collected half-smoked cigarettes, and Barbir's beads clicked faster. Each unit on the chits stood for about one million dollars.

"It's high stress, a young man's game. Some are burned out at 30," Barbir smiled. "They often get a few million dollars in the red before chalking up profits toward noon.

"Actually it's quiet today," he added. "The October crash, now that was hectic! We stayed at our screens for 48 hours nonstop. I wore out three strings of worry beads."

Although office blocks and apartments outflank the slender minarets along the gulf's urban southwestern shore, new wealth has not forsaken piety. Five times each day the muezzin's undulating call soars across the honk of traffic, summoning the faithful to their devotions.

In the blue-domed New Bazaar Mosque, amid the skyscrapers of Abu Dhabi, I joined thousands of believers for the Friday prayer and sermon. In the stalls under the mosque's shaded porticos I paused to admire the finely bound Korans and coral prayer beads for sale, then bought a cassette recording of the scriptures. A perfume merchant daubed my wrists with samples of his pungent rose attar. Inside, white-robed Bedouin and local bureaucrats mixed with a confetti of Muslim expatriate workers—Pakistanis, Sudanese, Baluchis, Iranians, Egyptians—to fill an acre of thick carpets under cool banks of high ceiling fans.

"Forget not the day of judgment! Repent your sins!" shouted the tall, thin imam from his high wooden pulpit. He wore a long gray gown with enormous sleeves and a red fez wrapped in white. His stern voice, raised by loudspeakers to rolling thunder, sent shivers down the kneeling rows.

"You cannot escape Allah's book," he warned. "*Wallahi! Wallahi!* It is written!"

LIKE BAHRAIN, Dubai lives off its wits as much as its oil. A village entrepôt for centuries, Dubai was still only a small port town when I first visited it 15 years ago. I had watched entrepreneurs from the gold suq loading bars of bullion into dhows with souped-up engines for the risky but profitable smuggling runs to India.

The old wooden dhows still bob beside the quays along what is called the Creek, but today the ancient harbor winds among the glass-and-granite towers of a modern city. Dubai's Trade Center tower, stretching up 39 stories, is the tallest in the Middle East. With tax-free vision, bold shipping ventures, and a wide-open trade policy, the City of Merchants, as it bills itself, is bent on becoming the Hong Kong of the gulf.

"The last 20 years we invested six billion dollars in roads, ports, and power plants," said Abdul Rahman al-Mutaiwee, director general of Dubai's Chamber of Commerce and Industry. "In a quarter of a lifetime we moved ahead a millennium. And it paid off.

"Our modern Port Rashid, capable of storing 30,000 containers, is filled to capacity," he continued. "So down the coast we built Jebel Ali industrial port. Jebel Ali's industrial zone, with tax-free sites, duty-free shipping, and cheap labor and power costs, has already installed 160 international companies—like Xerox, Black & Decker, and Safeway.

"Dubai Drydocks can repair the biggest tankers afloat. Some said we overbuilt. But the dry dock is busier than ever now with war casualties."

Three-fourths of the merchandise unloaded in Dubai is reexported, by freighter to India, Pakistan, and East Africa or by coasters farther up the gulf's risky channels to Saudi Arabia and Kuwait. But most shuttles across in dhows to the smaller ports of southern Iran, Dubai's biggest single customer.

I walked down past Dubai's Shiite mosque through noisy covered suqs to the ferry landing near the ruler's office and boarded a narrow wooden *abra*, one of dozens of water taxis that ply the Creek. Two bridges and a four-lane tunnel speed cars and expensive taxicabs across the harbor today, but Dubai's abra fleet offers a fast, scenic passage for only 25 fils (about seven cents).

Along the waterfront clogged with dhows five and six abreast, I threaded my way past longshoremen sweating cargos aboard: crates of Indian tea, Japanese video players, Dutch canned milk, Chinese wheelbarrows, Korean truck tires. On one of the larger craft, headed for Bahrain, crewmen lashed down cars and jeeps, filling spaces between with Taiwanese telex machines.

I paused at one typical vessel, about 50 feet on the waterline, square-backed with sweeping stern boards, a graceful sheer, and a high

stem. Baskets of onions and strings of drying fish hanging on the wheelhouse spiced the aroma of the falling tide. A cardboard sign in crude Arabic script announced the dhow's Iranian destination: IN THE NAME OF ALLAH—VESSEL TO BANDAR-E LENGEH—GHULAM ALI, MASTER.

Stripped to loincloths, two of the crew perched among frayed hawsers and rusty anchors on the bow, bathing from buckets; the tapping of the ship's carpenter floated out of the greasy engine hatch. The rest of the crew gathered on the sun-bleached deck amidships in the shade of a tarpaulin, taking turns on a clay water pipe. One waved me aboard. Between puffs of the mild Iranian leaf we talked about the booming cargo business: dates, dried lemons, fancy metalwork, and fine carpets from Iran for Dubai's tax-free consumer goods; about the sudden monsoon squalls that harass the smaller dhows; about the cost of diesel spares—and, inevitably, about the war.

"The Americans are *shaitans*, devils. Nothing personal, mind you. It is your government," the sailor said. "The Iraqis started this war; they attacked your warship, killed your sailors. How can you side with them?"

ECHOES of an earlier conflict resounded when I was granted an audience with Sheikh Sultan bin Muhammad al-Qasimi, who rules the nearby emirate of Sharjah. A gracious, expansive man clad in traditional red-and-white headcloth and gold-trimmed cashmere robe, he is a descendant of the Qasimi tribe of seafarers, who controlled the Strait of Hormuz and fought running battles with the British for half a century before being subdued.

As we sipped tea from fine crystal cups, a score of his Bedouin retainers leaned on their rifles just outside the door; beyond, a squad of uniformed soldiers patrolled the high, crenellated palace walls. Bullets had impeached one

Dubai *A pull from a water pipe occupies an Arab as two hatless Iranian seamen relax before sailing for home. Tradesmen from Iran thread dangerous waters to bring in carpets and handicrafts to exchange for appliances and other scarce consumer goods.*

of Sharjah's recent rulers; only last year my host had survived a takeover attempt by his older brother.

A man of two worlds, Sheikh Sultan had just published a book, *The Myth of Arab Piracy in the Gulf*, based on his Ph.D. thesis at England's University of Exeter.

"During the 18th century our family ruled ports on both sides of the gulf, commanding a prosperous trade with 500 ships," the scholar-sheikh explained. "Digging through the Bombay Archives, I was able to document my case: Our sailors were not pirates—they were only defending their native waters.

"History is written by the victors, they say, and the British published most accounts of that period. So in Western eyes pirates we remain," he said. "I hope my work will help lend balance to the gulf's history."

FROM "SHIPS OF THE DESERT" the gulf nations traditionally ruled their other sea, the vast waves of Arabian sand. For millennia the camel dominated life and culture as warrior's mount, bearer of cargo, reservoir, measure of wealth, and source of milk, hides, and wool. Its lilting canter drove the beat of Arab poetry and music. Now in one generation the camel stands obsolete as Bedouin move into town houses, as highways link together

the scattered oases and jeeps patrol the dunes. What may save the beast from extinction is the growing popularity of camel races. In winter Sharjah holds them every other Friday.

I arrived in dust and darkness at the desert racecourse near the oasis of Adh Dhayd as Bedouin lined up the first 30 camels for a sunrise start. Bedouin trainers helped the tiny jockeys, Pakistani and Bangladeshi boys six to ten years old, into special Velcro saddles that locked them on by the seat of their pants. Many wore walkie-talkies strapped to their chests. Behind the starting line another 250 bawling beasts waited for their heats. Officiating at the event from the front seat of his Range Rover was Sheikh Sultan's once defiant brother, Abdul Aziz, now Sharjah's deputy ruler.

"The races keep alive one of our most important traditions," Sheikh Abdul Aziz said, as AK-47-toting bodyguards poured rounds of coffee from a shiny brass thermos.

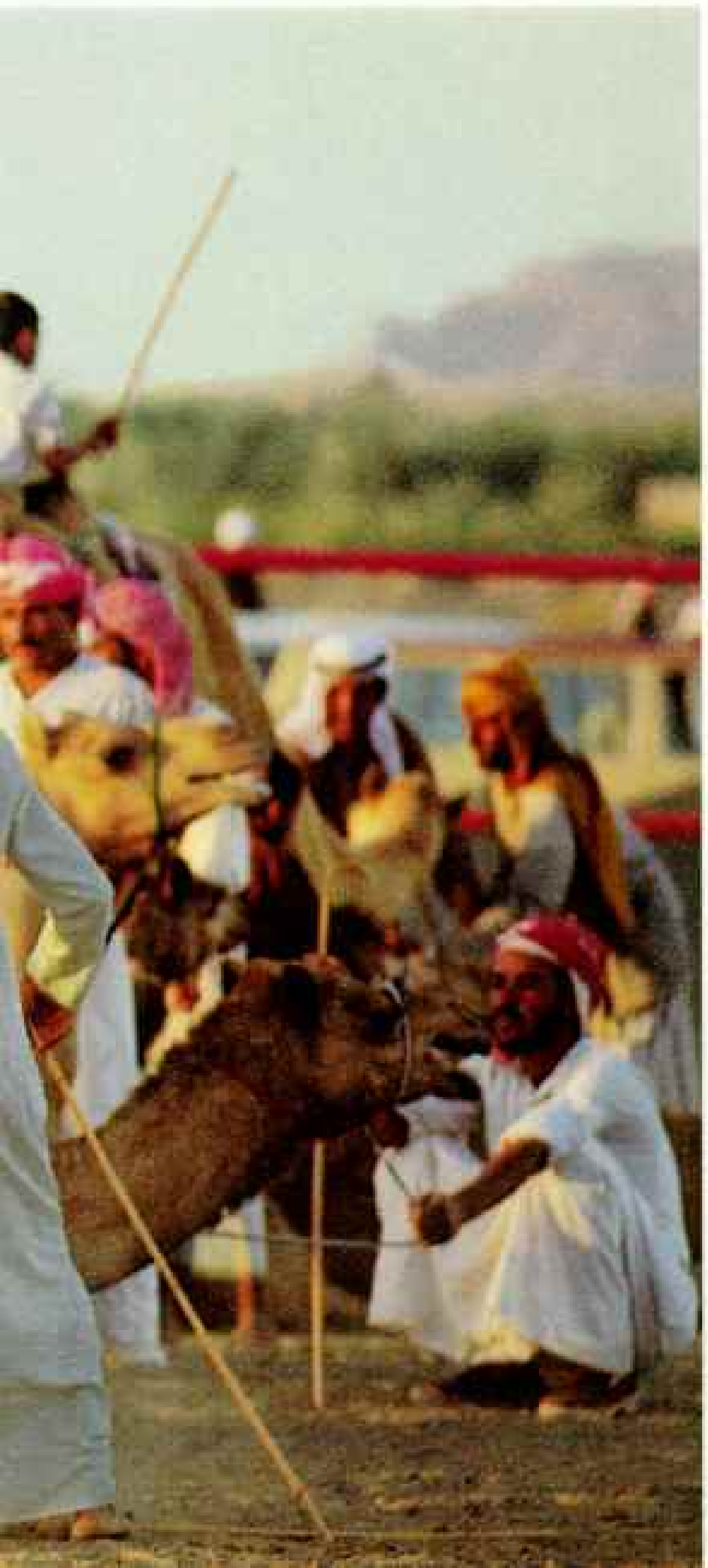
"I encourage the sport. I brought 36 camels to race today," he said. "Of course racing improves the breed. A top thoroughbred camel—like the famous *Tiyara* [Airplane]—can bring two million dirhams, about $600,000," he added, then raised a hand signal.

Bang! went the starting gun, followed by cheers and shouts as the camels began their six-mile, straight-line lope across the desert with a fleet of jeeps and pickups, led by Sheikh Abdul Aziz, chasing alongside.

"Ya Allah! Ya Allah!" the trainers shouted into their walkie-talkies—"For God's sake, hurry!"—long after the spectacle was swallowed by its own cloud of early morning dust.

Here in Sharjah, as throughout the gulf, centuries still collide, on a dusty camel concourse or in the high-risk race for oil offshore. Despite the war, life goes on, but eight troubled years have whetted a thirst for peace.

Only then can the gulf states find their winning stride. □



Sharjah *Complaining camels tended by Bedouin are pulled to the starting line for a race in Adh Dhayd. Coffee is poured for a front-seat spectator, Sheikh Abdul Aziz, the deputy ruler, as a bodyguard stands near. His AK-47 is a common sight in the oil-rich nations that rim the troubled gulf.*

FLEAS

The Lethal Leapers

ARTICLE AND PHOTOGRAPHS BY NICOLE DUPLAIX

BIANCA LAVIES (ABOVE)

Its meal at its feet, a cat flea magnified 120 times burrows through the fur of its host. Intricate, adaptable, bloodsucking parasites, members of this insect order can survive months without food, withstand tremendous pressure, and leap 150 times their own length.

But there is a darker side: As carriers of plague, fleas have claimed more victims than all the wars ever fought. Sentinel of horror, a skull and crossbones decorates an ossuary built on the site of a mass grave of 14th-century plague victims in Rouen, France.

OUR HELICOPTER skimmed at treetop level, the desert beneath us a dizzying blur. "Keeps us off unfriendly radar screens," commented the South African pilot wryly, as the copter lurched to dodge a tall palm.

We had entered the troubled border area between Namibia and its northern neighbor Angola. But I had come to investigate a far older war—man's battle against plague. It stalked the Namibian sands below, one of many plague zones that survive worldwide, despite ceaseless efforts to control this disease.

I glimpsed a fenced cluster of huts. Flea-control teams under the protective eye of soldiers were dusting the kraal with clouds of DDT. Around it corn crops lay shriveled: Drought was inflicting its misery—and helping spread plague.

"Wild gerbils, starved by the drought, seek food stored in the kraals," explained Professor Margaretha Isaäcson, a doctor from neighboring South Africa. "The rodents bring plague with them, and fleas for spreading it."

In the hospital in Oshakati I leaned over 11-year-old Monica Sherugeleni and smiled. Shyly she lifted her arm to show me a swelling the size of my palm in her armpit. Warm and firm to the touch, it was a bubo, the symptomatic growth that gives the name to bubonic plague.

"Cases number in the hundreds, and the season isn't over yet," said Maj. Neels de Villiers, head of South Africa's 58 doctors on the scene. "Young children, two to three years old, usually recover. Older patients sometimes develop septicemia or meningitis, and these may die. But our mortality rate is only 4 percent, lower than yours in the States."

Accomplices of plague, fleas evolved as highly specialized bloodsucking parasites at least 60 million years ago, probably living on prehistoric mammals. Their ancestors may have had wings, but these would have tangled in the host's fur. Jumping provided an alternative means of reaching a passing host or evading enemies. Gradually muscles and tendons were modified to help power the formidable hind legs that make the flea a star performer, a true insect Olympian.

Fleas of various species can

- jump 150 times their own length—vertically or horizontally—equivalent to a man jumping nearly a thousand feet;
- survive months without feeding;
- accelerate 50 times faster than the space shuttle;
- withstand enormous pressure—the secret to surviving the scratchings and bitings of the flea-ridden;
- remain frozen for a year, then revive.

In the 17th century when the Dutchman Anton van Leeuwenhoek was perfecting the microscope, he chose the flea as a subject for scrutiny. His observations aroused such interest that the microscope became known as the "flea glass." To great merriment Leeuwenhoek discovered that these minute parasites had parasites of their own, a web of predation that evoked Jonathan Swift's sally:

> *So, naturalists observe, a flea*
> *Hath smaller fleas that on him prey;*
> *And these have smaller still to bite 'em,*
> *And so proceed* ad infinitum.

But for millennia the disease spread by fleas has been no laughing matter. Plague may have originated among burrowing rodents of central Africa and central Asia. When plague broke out in a rodent population—quickly

STEPHEN DALTON (FACING PAGE); RENE COX

WITH THE GREATEST OF EASE, a cat flea springs into a somersault in a multiple exposure. Its acceleration of 140 g's is almost 50 times the acceleration of the space shuttle after lift-off.

The mechanics of jumping hinge on a superelastic protein known as resilin (above) located in the thorax above the insect's hind legs. Leg and thorax muscles compress the resilin; its release catapults the flea upward. Aloft, the flea tumbles and extends its legs to snag a passing host.


0 500 km
0 300 mi
Trier
Clermont-Ferrand
Lyon
Narbonne
Marseille
Ravenna
Rome
(Carthage)
Black Sea
Caspian Sea
Istanbul (Constantinople)
Antakya (Antioch)
Mediterranean Sea
Alexandria
(Pelusium)
Red Sea
Plague from central Africa
FIRST PANDEMIC
A.D. 541-44 First epidemic
A.D. 557-767 Fourteen successive epidemics
Plague route
Atlantic Ocean
Trondheim
1349
Oslo
Stockholm
1350
Moscow
1351
1352
Dublin
1349
LONDON
Plague was endemic in London beginning in 1348 and ending with the Great Plague of 1668 that claimed at least 68,000 lives.
London
Amsterdam
Rotterdam
Antwerp
Aachen
Lübeck
Gdańsk (Danzig)
1350
Erfurt
Warsaw
Kiev
Rouen
Paris
1348
Mainz
Strasbourg
Nürnberg
Munich
1349
Vienna
EUROPE
Bordeaux
Lyon
Budapest (Buda, Pest)
Venice
Trieste
Milan
Toulouse
1348
Marseille
Genoa
Florence
Ancona
1350
Feodosiya (Kaffa)
Crimea
Black Sea
Bucharest
Lisbon
1349
Barcelona
Livorno (Leghorn)
Rome
Dubrovnik (Ragusa)
Istanbul (Constantinople)
Valencia
Seville
Balearic Islands
1347
Naples
Algiers
Oran
1348
Tunis
Messina
Sicily
1349
Izmir (Smyrna)
Cyprus
Mediterranean Sea
AFRICA
Tripoli
Alexandria
1348
Cairo
SICILY
Plague landed in western Europe at Messina, Sicily, in October 1347 when plague-ridden galleys arrived from Black Sea ports in the Crimea.

Plague's relentless advance: the geography of terror

THE DEADLY TENTACLES of plague reached across the Mediterranean from Africa during the first pandemic, beginning in A.D. 541 (inset map). This disease of rodents, carried to man by fleas, reached Constantinople within a year; 10,000 died there daily as the infection peaked.

Cities were abandoned, agriculture declined, populations plunged, trade faltered. After 200 years, plague mysteriously vanished from Europe. Six plague-free centuries passed. In 1346 it returned, traveling in the wake of caravans and ships that plied trade routes between Asia and Europe. The unwanted import landed at ports like Marseille and Genoa and pushed inland. Cities suffered most; the contagion spread quickly in crowded, filthy conditions. By 1352, 25 million people had died in Europe alone.

Death's scythe cut across all levels. Peasants dropped dead in fields. In England three archbishops of Canterbury died within one year. Fear suspended other emotions. "This disease is making us more cruel to one another than we are to dogs," English diarist Samuel Pepys wrote in 1665. Corpses were dumped in pits, in rivers, at sea. "Father abandoned child, wife husband, one brother another. . . . And I, Agnolo di Tura . . . buried my five children with my own hands," recorded a chronicler in Siena, Italy. With few to work fields, peasants could demand higher wages; cracks in the manorial system widened. Added di Tura: "So many died that all believed that it was the end of the world."

reducing the numbers—rodents from neighboring colonies moved in, picked up the infected fleas, and spread the disease.

When plague entered the human population, the consequences were catastrophic. The first outbreak may have been a scourge that struck the Philistines in the 12th century B.C.; the Old Testament account mentions "mice that mar the land."

Later three plague epidemics—so vast they were called pandemics—ravaged the world. The first struck in A.D. 541, swirling around the Mediterranean in a deadly maelstrom for more than two centuries, killing as many as 40 million people and weakening the Byzantine Empire. "The bodies of the sick were covered with black pustules . . . the symptoms of immediate death," wrote Procopius, historian of Byzantine Emperor Justinian. At its peak in Constantinople, he reported, the plague killed 10,000 people a day.

NICOLE DUPLAIX received her doctorate from the University of Paris for studies of South America's giant otter, the subject of her first GEOGRAPHIC article in July 1980. Editor of publications for the South Florida Water Management District, she is active in wildlife conservation.

THE SECOND PANDEMIC came in the 14th century, when lucrative trade routes opened across Asia. Caravans and ships brought more than silk and jewels. In October 1347 vessels sailed into Messina, Sicily, with crews dying from a mysterious disease. No one noticed that shipboard rats were also ill.

The next five years were so devastating that they became known as the time of the Black Death. By 1352, plague had killed 25 million people in Europe alone.

Feverish victims suffered excruciating swellings in the groin or armpit—the buboes. Most died within five days. Sometimes the infection spread via the bloodstream to the

d Casualties this Week,

Impofthume	11
Infants	16
Killed by a fall from the Belfrey at Alhallows the Great	1
Kingfevil	2
Lethargy	1
Palfie	1
Plague	7165
Rickets	17
Riling of the Lights	11

"THEY DIED IN HEAPS and were buried in heaps," wrote English novelist Daniel Defoe. A weekly death census taken in London in September 1665 tallies victims (above). One doctor rued, "Now people fall as thick as leaves from trees in autumn."

St. Roch, a patron saint of plague, painted by the 15th-century Venetian Carlo Crivelli, points to a bubo, the lymphatic swelling symptomatic of bubonic plague (left). Sufferers believed the saint could cure. Though their role in plague transmission was as yet unknown, fleas were part of daily life. Blood-soaked cloth may have been inserted in this 17th-century English ivory flea trap in hopes that the insects would enter the trap and spare the wearer.

GALLERIE DELL' ACCADEMIA, VENICE (LEFT)

National Geographic, May 1988

lungs; then death came in three days or less. This was pneumonic plague, the deadliest form then and today.

Looking for scapegoats, Europeans massacred Jews, suspected of poisoning the water. Neighbors turned on neighbors, parents turned on children. The sick were walled up in their houses and later quarantined on islands. To no avail. So many died so quickly that cities dug plague pits for the corpses. With no escape, no cure, "there was no one who wept for any death, for all awaited death," wrote Agnolo di Tura, a chronicler in Siena, Italy.

"The worst thing was finding no explanation for the greatest natural disaster Europe had ever known," Professor Henri H. Mollaret and Jacqueline Brossollet, plague historians at the Institut Pasteur in Paris, told me.

The church saw the plague epidemic as a manifestation of God's wrath. A committee of doctors at the University of Paris pronounced that it was the sinister result of the conjunction of Saturn, Jupiter, and Mars. A common belief that plague was caused by "corrupt vapors" gave birth to the macabre doggerel that children still recite today:

Ring around the rosies,
A pocket full of posies,
Achoo! Achoo!
We all fall down.

A nursery rhyme? Hardly. Rosies were the pink rash associated with plague; posies were the nosegays carried to perfume the corrupt vapors. Sneezing was brought on by feverish chills; then all fall down, dead.

As the sweeping scythe of plague turned bustling towns into sepulchers and emptied the countryside, it reshaped European society. With few serfs left to till the land, survivors could negotiate for wages with landlords. The breakdown of manorialism and the evolution of an economy based on money sowed seeds of capitalism. *(Continued on page 684)*

HELL ON EARTH, the nightmare depicted by Flemish painter Pieter Bruegel in his mid-16th-century "The Triumph of Death" reflects the social upheaval and terror that followed plague. Desperate for an explanation, people blamed the planets, God, and each

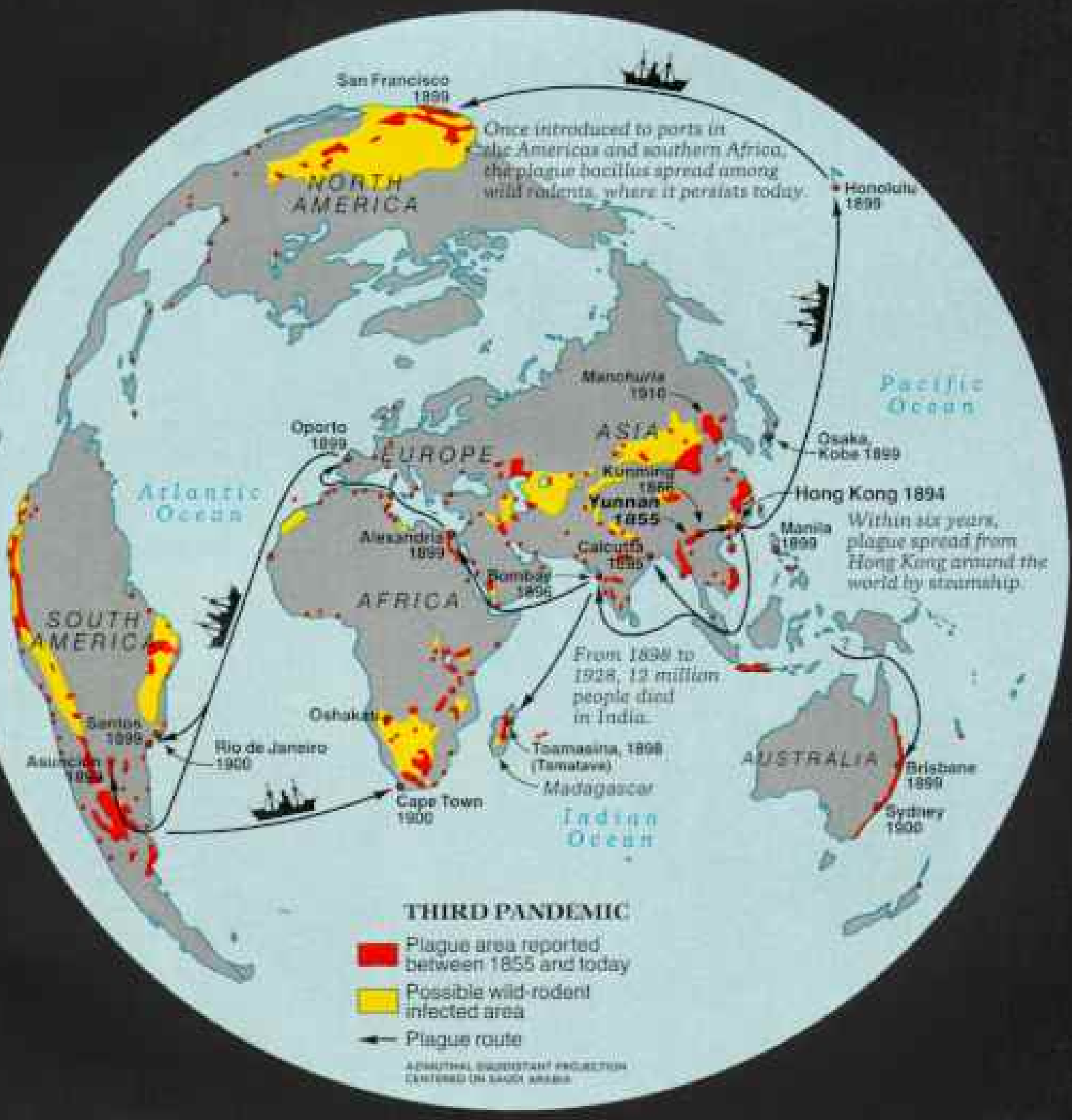
MUSEO DEL PRADO, MADRID

other. In 1348 Jews in France were dragged from their houses and burned. Pogroms occurred throughout Europe. Reportedly 6,000 died in Mainz, Germany; 3,000 in Erfurt. When plague subsided, few Jews were left in Germany or the Low Countries.

Plague encircles the globe

THE SPREADING STAIN of plague tainted the world yet again when the third pandemic erupted in China in 1855. Reaching Chinese ports in 1894, it was carried around the world. That year Dr. Alexandre Yersin (facing page), a Frenchman sent to plague-riddled Hong Kong by the Institut Pasteur, identified the plague bacillus. The next breakthrough came in 1898 when Frenchman Dr. Paul-Louis Simond discovered that fleas transmit plague from rats to man. Because of the virulence of the pneumonic plague that overwhelmed Manchuria in 1911, a doctor examining a patient wore a gown and mask (right). But plague remained untreatable until the advent of sulfa drugs in the 1930s and effective antibiotics in the 1940s.

INSTITUT PASTEUR, PARIS



Mon voyage à Hong-Kong

ON THE OFFENSIVE, a plague-control worker sprays a village in northern Namibia for fleas. Dr. Margaretha Isaäcson, senior advisor to South Africa's plague-control program, inspects the hut of a recovered patient who has returned to her village after being hospitalized. In 1986 the World Health Organization tallied 1,003 cases of plague, but statistics mislead; many countries fail to report the disease.

Plague struck without pattern, skirting one area only to bludgeon another. Busy ports such as Venice, Marseille, and Barcelona endured dozens of outbreaks. England took 200 years to recover from its 14th-century death toll. In the Great Plague of 1665 at least 68,000 Londoners died. Survivors cowered behind shuttered windows as the body collector cried, "Bring out your dead!"

In man, plague enjoyed an unwitting ally. Families crowded in houses where rats were tolerated and hygiene did not exist. People wore the same underclothes day and night. Fleas and lice thrived and went along when the clothes of the dead were sold or passed on.

As the second pandemic raged and waned through the centuries, chroniclers came tantalizingly close to the mysterious cause of the disease. Observed Chinese poet Shih Tao-nan in 1792, shortly before succumbing to plague: "Few days following the death of the rats, Men pass away like falling walls!"

IN THE LATE 1800s the third pandemic spread plague around the world. It lingers today. Carried out of China's Yunnan Province in 1855, plague traveled slowly east; by 1894 it reached Hong Kong, where it killed some 10,000 people.

In this charnel house a young French bacteriologist unmasked the pestilence.

Alexandre Yersin had been sent by the Institut Pasteur to investigate the epidemic. Examining a plague victim, he found in the buboes "a swarm of microbes, all similar in appearance . . . short bacilli with rounded ends."

One part of the puzzle had been solved. But how was the guilty bacillus transmitted?

As Hong Kong's death toll mounted, hundreds of ships docked and departed with their familiar complement of rats. Steamships now carried the disease even faster, before unsuspecting crews became ill. Plague fanned out to where it had been unknown: Japan, Australia, southern Africa, and the Americas.

India, the site of earlier outbreaks, was especially hard hit; six million died in a decade. Once again the Institut Pasteur sent help, this time Dr. Paul-Louis Simond.

Walking filthy city streets, he observed dead rats littering plague-ridden neighborhoods—75 in one house alone. Humans who picked them up, he noted, soon fell ill themselves. In his makeshift Bombay laboratory, a tent pummeled by the monsoon, Simond dissected rats and found the plague bacillus. These plague rats, he observed, carried far more fleas than healthy ones. He also noted that, contrary to common belief, the rat flea readily bit man.

Rats . . . bacilli . . . fleas . . . . Simond had the connection. Rats were plague's natural host but could not themselves transmit the disease to man. Fleas engorged with contaminated rat blood, however, could transmit plague from rat to rat—or rat to man.

"On June 2, 1898, I was overwhelmed," Simond wrote. "I had just unveiled a secret which had tormented man for so long." Though his discoveries went generally unrecognized for a decade, they helped form the basis for modern plague control.

Today we suspect that of the more than 2,400 known species and subspecies of fleas, perhaps only 120 can transmit plague. Fewer than 20 species readily bite man.

Transmission of plague requires precise

TO RAISE FLEAS, researchers at Cornell University's College of Veterinary Medicine developed an artificial dog, a network of blood-filled glass feeding chambers.

A rodent's burrow may have been the source of infection for Carl Weinmeister of Santa Fe, New Mexico. In 1983 he survived plague caught from a flea that one of his pets picked up from an infected rodent.

MICHAEL GREENLAR

Getting a jump on fleas

Fleas in the house? Here's how to cope:

1. *Start early.* Don't wait until they get the upper hand during peak summer breeding season. As the old saying goes: "If you kill one flea in March, you will kill a hundred."

2. *Vacuum weekly.* One of the most effective measures is to suck up fleas, along with eggs, larvae, and pupae. Add a little flea powder to the vacuum bag. Spray an insecticide recommended by your veterinarian in closets and along baseboards where a vacuum won't reach.

3. *Shampoo your pet* with flea soap and dust it with flea powder. A loose flea collar may also help.

4. *Sprinkle borax* or an insecticide recommended by your vet on your pet's bed and favorite haunts.

5. *Still scratching?* Call a professional exterminator.

meshing of a complex chain of events. To give you plague, the right type of flea must first bite a rodent infected with plague and pick up the bacillus. The microbe incubates in the flea's digestive tract, where it multiplies and eventually blocks the gut. If the now starving flea bites you in a fruitless attempt to feed, it will inject countless plague bacilli into your bloodstream. Just one can lead to death.

TO KEEP PLAGUE in wild rodents from spreading to man, our leading weapon is insecticides. Spraying for fleas with DDT, Burma, Vietnam, India, and southern African nations have scored major victories against plague. But war or social upheaval can interrupt these programs, giving fresh opportunity to what one doctor called "the enemy in ambush."

During the Vietnam War soldiers and civilians sought protection from shellfire in underground mazes. Bandicoot rats and other rodents adopted these convenient burrows. Between 1965 and 1970 official reports listed 24,848 cases of plague. Thanks to antibiotics, 96 percent of the victims survived.

"Plague mistakenly still carries a terrible stigma, something governments feel they should be ashamed of," said Dr. Norman G. Gratz, the World Health Organization (WHO) official in Geneva in charge of keeping tabs on plague control around the world. He told me of a doctor who worked with one country's local health officials setting up a program to check rampant plague and then paid a courtesy call on the minister of health.

"We used to have many cases annually," said the minister glibly. "Thanks to our control measures, we've had none in 30 years." Officially plague did not exist.

The United States once did the same. When plague came ashore in San Francisco on June 27, 1899, political leaders, protecting business interests at the expense of disease control, overrode health officials and denied its presence. The governor decreed it a felony to publicize its existence. By 1904, more than 100 people had died of "syphilitic septicemia," the official pseudonym of plague.

Western Americans still pay for that deceit. Infecting one wild rodent population after another, the disease made a macabre march inland. Today 13 states live under its cloud. A result: Forty Americans contracted plague in 1983; six died. Last year there were 12 cases;

two victims succumbed. Most cases occur in Arizona and New Mexico. Here plague-prone ground squirrels and prairie dogs live as close as one's backyard.

Because plague occurs infrequently in the U. S., it is not always recognized.

"The disease is difficult to diagnose," explained Dr. Allan M. Barnes, director of the Center for Disease Control's plague branch in Fort Collins, Colorado. "Patients may be suspected of having flu or some other virus and sent home with prescribed medication, which has no effect. By the time they call the doctor again, they're critically ill."

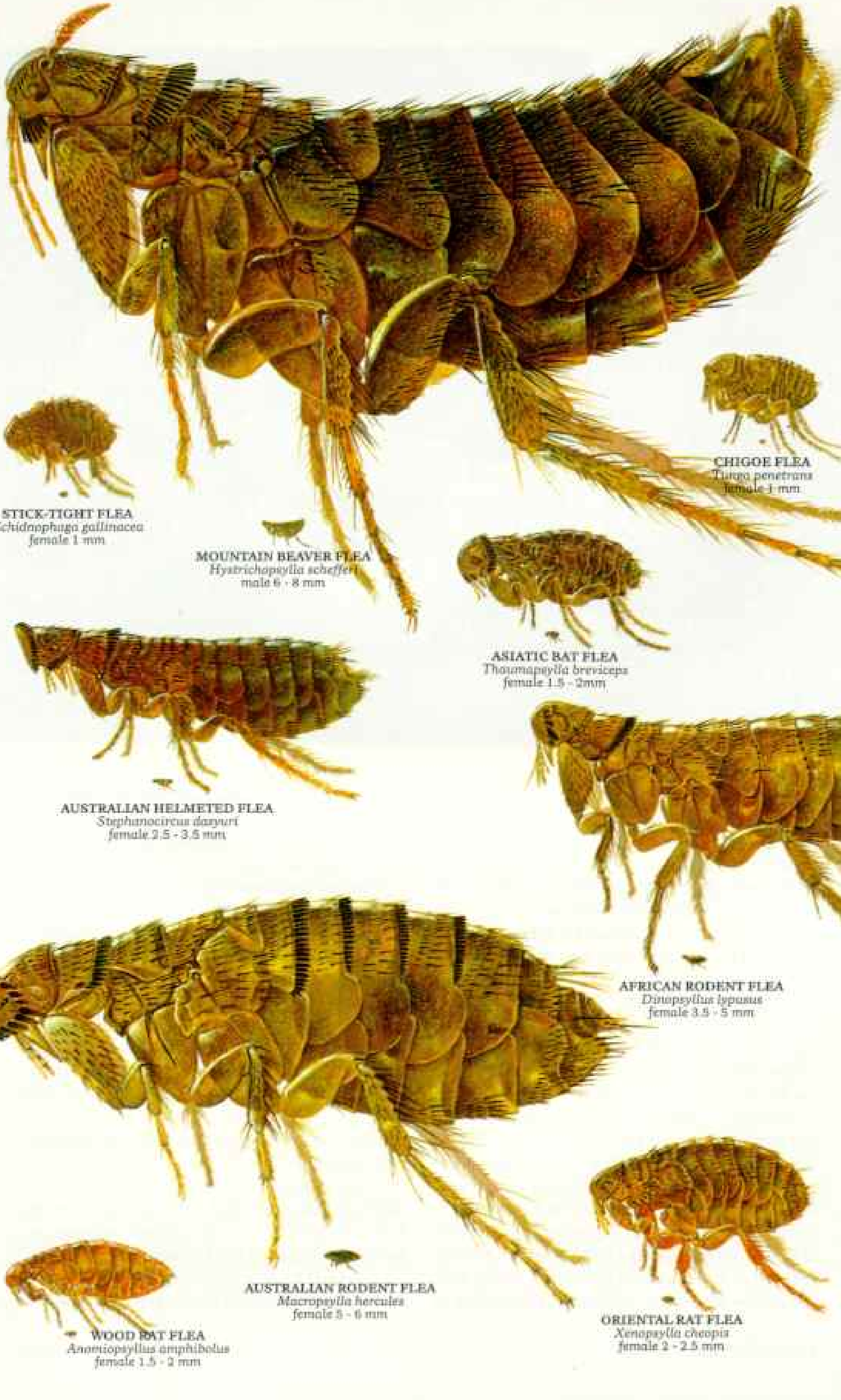
The peril is greatest if you come down with the disease in a plague-free area. In 1983 a teenage girl who had petted a sick chipmunk in Santa Fe died of pneumonic plague in South Carolina on her way home to Maryland. Local doctors never thought of testing for plague. Whereas an estimated 2 percent of plague victims die in Burma and 8 percent in South Africa, in the medically advanced U. S., due to this unfamiliarity, the death rate is 17 percent.

To predict where plague will strike next, Western health officials keep a check on wild rodent populations.

"We are concerned about plague outbreaks among wild rodents anywhere there is risk to humans," said Dr. Bernard Nelson, head of California's plague-monitoring team. "The main threat is in urban settings. In recent years we have trapped 'positive' rodents in Griffith Park, in downtown Los Angeles. Plague is endemic in the San Bruno Mountains, right next to San Francisco International Airport. But the flea species that live there don't bite people."

Like control, plague treatments have greatly improved.

"The slower bubonic form is easily cured with antibiotics," said Dr. Thomas Kereselidze of WHO. "But pneumonic plague, infecting the lungs, is fatal 95 percent of the time. The patient must be isolated and given antibiotics very quickly if he is to survive. Worse, the



STICK-TIGHT FLEA
Echidnophaga gallinacea
female 1 mm

CHIGOE FLEA
Tunga penetrans
female 1 mm

MOUNTAIN BEAVER FLEA
Hystrichopsylla schefferi
male 6 - 8 mm

ASIATIC BAT FLEA
Thaumapsylla breviceps
female 1.5 - 2mm

AUSTRALIAN HELMETED FLEA
Stephanocircus dasyuri
female 2.5 - 3.5 mm

AFRICAN RODENT FLEA
Dinopsyllus lypusus
female 3.5 - 5 mm

AUSTRALIAN RODENT FLEA
Macropsylla hercules
female 5 - 6 mm

ORIENTAL RAT FLEA
Xenopsylla cheopis
female 2 - 2.5 mm

WOOD RAT FLEA
Anomiopsyllus amphibolus
female 1.5 - 2 mm

Nature's hitchhikers

MINI-SPLENDORED THINGS, fleas are found nearly everywhere, even in the polar regions. More than 2,400 species and subspecies have been described. The majority live on mammals; a few infest birds. An assortment of fleas (left) illustrates variations in their shape, size, and host preference. Each flea is enlarged 20 times above its life-size rendering.

Fleas live for as little as a few weeks or as long as a year or more. As parasites, their first order of business is to find a host, then hop aboard. To accomplish this, they are equipped with antennae and bristles sensitive to heat, vibration, and air currents. They can also sense carbon dioxide exhaled by a passing host.

Fleas are living burrs, studded with bristles and combs. They need all the clinging power they can get, faced with continual rejection by unwilling hosts who attack with tooth and claw. Flea bodies, flat from side to side, allow them to maneuver between fur hairs. Mouth parts consist of sawlike lances that penetrate skin and a blood-siphoning tube. Some fleas feed quickly and leave their host; others remain fixed, imbibing when hungry.

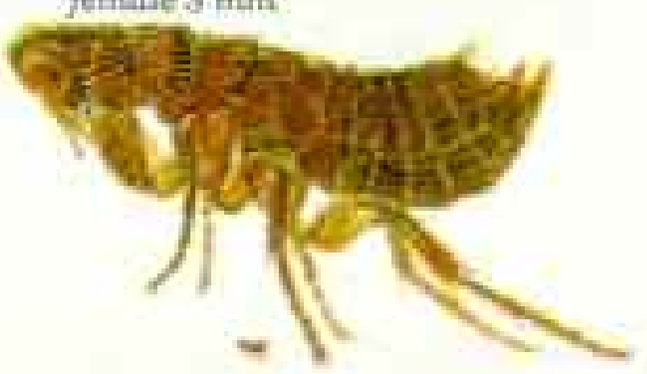
In South and Central America and Africa the female chigoe flea burrows into the skin of man and other hosts to undergo a little-studied reproductive cycle. Embedded head down (bottom, at left), she expands from the size of a pinhead to the size of a pea in eight to ten days and fills with eggs. If a male then mates with her, the hundreds of eggs she releases, right, will be fertile. The flea must be cut out, or infection may ensue. A traveler who went barefoot in an infested area had this infection to show for it (left).

GUILLERMO ALDANA E.

PAINTINGS BY JOHN DAWSON

BIRD FLEA
Ceratophyllus garei
female 2.5 - 3.5 mm

EUROPEAN MOUSE FLEA
Leptopsylla segnis
female 3 mm



EUROPEAN MOUSE FLEA
Leptopsylla segnis
male 2 mm

HUMAN FLEA
Pulex irritans
male 2 - 3 mm

CAT FLEA
Ctenocephalides felis
female 2 - 3 mm

patient only has to cough or sneeze to transmit it to others."

No one believes that plague will ever be eradicated.

"There is a vaccine, but it is not totally effective and lasts only six months," explained South Africa's Margaretha Isaäcson. Yet in plague-rife Vietnam only a few vaccinated U. S. soldiers contracted the disease.

Wiping out the rodents that harbor plague is impossible—and undesirable during outbreaks of the disease. "If you killed all plague-carrying rodents," said Dr. Isaäcson, "their fleas would seek another host, and it could be you! Rodent control should be practiced when there is no danger of depriving infected fleas of their hosts."

Three pandemics, killing more than 200 million people. . . . Only disease-carrying mosquitoes have caused as much misery as this fascinating order of insects aptly called Siphonaptera—"wingless siphons." Yet for generations we have not only tolerated these pests, we have used them for entertainment.

THE CIRCUS was in full swing. The patrons waiting at the door were among the millions who flock to Munich, West Germany, each fall to attend Oktoberfest . . . and the celebrated flea circus.

THE DOYENNE OF FLEA EXPERTS, English naturalist Miriam Rothschild has written more than a quarter of a million words on the insect, including an analysis of how it jumps. Her father, a renowned entomologist, described the bubonic-carrying rat flea. As a young woman raising a family, she studied fleas at night after her children went to bed.

Earlier I sat across from Hans Mathes and watched one of the world's last flea impresarios feed his performers before the next show (pages 692-93). Sixty of them, some harnessed to tiny gold coaches, lined his arm sucking their meal of blood.

"Be careful!" Hans cautioned as I tried to focus my cameras on the brown specks. "Vibrations make them lose their appetite." But the fleas seemed unconcerned. For an hour they fed. Then he dropped them into the drawers of a tiny green chest and carried them to center stage.

Flea circuses have been a Mathes family tradition for more than a century. Great-uncle Orlof entertained Queen Victoria. Hans's father toured the fairs of Europe.

Hans prefers *Pulex irritans*, the human flea. He only uses the females, which, he says, are more active than smaller, "dumber" males. Was training really involved? I peered closely at Nero, pulling a gold chariot by fits and starts. A twisted gilded wire around Nero's thorax hitched the flea to the vehicle, preventing a leap to freedom. I knew that whatever the activity, and Hans's patter, the performers were only struggling to escape—normal flea behavior. If they get sluggish, Hans gently picks them up with tweezers and warms their feet with his breath.

One of the world's most distinguished flea experts lives on an estate near Cambridge, England. Miriam Rothschild (left) pulled out a well-thumbed photograph album as we chatted by the fire. Instead of snapshots I saw hundreds of cross sections of fleas, photographed under a microscope—the results of 10 years of work.

"Everything about fleas is unusual and fascinating. My father, Nathaniel Charles Rothschild, gave me the bug," she quipped. "He was a banker, but he spent his leisure hours collecting and cataloging fleas, describing hundreds of new species based on differences in their external anatomy. I prefer to focus on their internal structure, and I find as many differences there."

Rothschild's studies include a special examination of the flea's unique propulsion system—the secret to its awesome leaps.

Preparing for lift-off, the flea crouches like a runner waiting for the gun. Leg and thorax muscles compress a tiny pad of superelastic protein in the thorax known as resilin. A complex mechanism triggers the explosive release

BIANCA LAVIES (ABOVE AND TOP L); PAINTING BY JOHN DAWSON

RABBIT TRANSIT: Fleas parade down the nose of a host rabbit to her newborn to mate and lay eggs. Miriam Rothschild discovered that the reproductive cycle of the rabbit flea is cued by hormones in the pregnant rabbit's blood, ensuring that the next generation of fleas is born with the next generation of rabbits.

A cat flea larva ingests blood exuded by a feeding adult (top). Larvae molt several times, then spin a cocoon (above).

Fleas: The Lethal Leapers

of resilin energy that hurls the flea upward.

Blasting off, the flea experiences an acceleration of 140 g's, 50 times that of the space shuttle after lift-off. The flea catapults off its "knees"; the feet are too slender to withstand this shock.

Aloft, it may cartwheel end over end, seemingly out of control. No problem: Its six extended legs, covered with bristles and tipped with hooks, act as grappling irons to snag onto fur or feather.

Powered by its resilin mainspring, the flea can leap tirelessly again and again. Rothschild and a colleague, testing the stamina of rat fleas, clocked one flea jumping 30,000 times without stopping. Bat fleas, which must stay with their aerial hosts, lack resilin altogether.

FLEAS FALL into three basic categories according to their movement patterns: sedentary fleas, stick-tight fleas, and mobile fleas—the kind we know best.

Jumping aboard a host only long enough for a meal, mobile fleas spend much of their lives in dark recesses of the nest, be it burrow, doghouse, or your carpet. Here they deposit their eggs, which soon hatch into larvae that encase themselves in a cocoon to transform into pupae. If the host is away, the pupae remain dormant until its return, then spring up as adult fleas in voracious greeting.

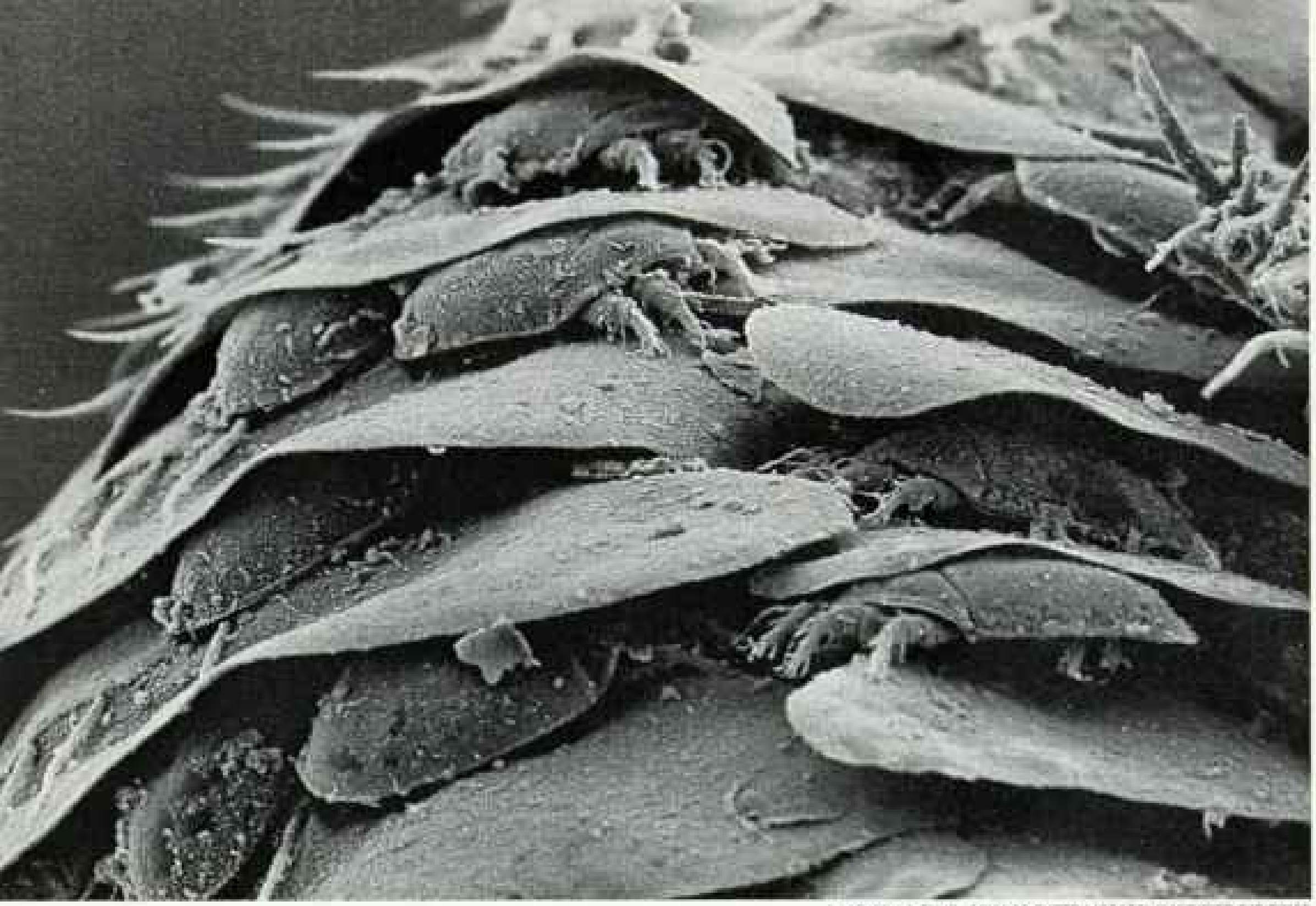
Sedentary fleas ride their hosts wherever they go, sucking blood when they are hungry. One such female flea found on livestock in Asia produces eggs by the thousands, stretching her abdomen to nearly three-quarters of an inch—the longest flea in the record book.

Partial to livestock and people, stick-tight fleas attach themselves to hosts for long periods of time. The female chigoe flea carries this attachment to extremes. She burrows into the host's skin, then swells to the size of a pea, causing painful welts all too familiar to those who live in the tropics. Yet the male of a related stick-tight flea species—born only to breed—never feeds during his short life.

A flea that dwells mainly on the ears of rabbits became a link in the great myxomatosis outbreak of the 1950s, which almost exterminated the rabbit populations of Australia and Europe. Transmitted by mosquitos in Australia, the viral disease was spread in Great Britain by rabbit fleas. Investigating, Miriam Rothschild encountered a life cycle so subtle

THE SMALLEST SHOW ON EARTH might well be the Munich flea circus ringmastered by Hans Mathes, here feeding his troupe. But performers are hard to find; "German houses are too clean," he says. A flea is hitched to a tiny carriage by a gilded wire (right). Other fleas dance, juggle, and propel a Ferris wheel, but the performance is actually a struggle to escape.

Dead fleas dressed as bride and groom (left)—a craze of the 1920s—were done as a novelty by a flea researcher in the 1940s.



CATHERINE ELLIS, SCIENCE PHOTO LIBRARY; MAGNIFIED 240 TIMES

CHINKS IN THE ARMOR, spaces between the cuticle plates of a flea's exoskeleton provide a toehold for mites, which hitch a ride on their host. Thus the flea saga, an interplay between host and parasite, recapitulates itself on an even smaller scale.

and complex that it took her nearly three years to unravel it.

Rabbit fleas, she discovered, have handed over to their host a vital decision—when to breed. "The fleas cannot reproduce unless the female rabbit becomes pregnant," said Rothschild. "As the rabbit's pregnancy progresses, hormone fluctuations in her blood also affect the fleas, triggering each phase of their own reproductive cycle."

Ten days before the rabbit litter is due, the fleas begin to mature sexually. As the mother rabbit licks her newborns dry, the fleas migrate to the young. Tarrying long enough to mate and lay eggs in the nest, they thus ensure that the next generation of fleas is born with the next generation of rabbits.

Fleas have many ways of locating their preferred sources of food. A host's body heat and odor, subtle changes in light and shadow, traces of carbon dioxide exhalation—all can give cues to the flea's finely tuned sensors. The bristles on a saddle-shaped organ near the flea's tail may serve to detect shifts in air movements, a further clue to the proximity of a potential host.

IRONICALLY, man is unique among the primates in having fleas, perhaps because this naked ape wears clothes for fleas to hide in and lives in houses—large burrows of sorts. Through the ages we have been of two minds about fleas: to put up with the itch or to fight back. In times past, women wore flea traps in their bodices. The perforated wood or ivory cylinder, possibly holding blood-soaked cloth, was supposed to attract and capture the pests. Flea-repellent sachets were tucked between bed sheets.

I remember vividly a night spent with fleas in a hut in New Guinea; I would have given a lot for an effective flea trap then. To my surprise my male companions were hardly bitten.

"Fleas seem to prefer women," Rothschild confirmed. "Perhaps human fleas respond to female hormones the way rabbit fleas do. An interesting line of research. . . ."

I didn't volunteer my services. □

NATIONAL GEOGRAPHIC (ISSN 0027-9358) IS PUBLISHED MONTHLY BY THE NATIONAL GEOGRAPHIC SOCIETY, 17TH AND M STS., N.W., WASHINGTON, D. C. 20036. $18.00 A YEAR. $2.25 A COPY. SECOND-CLASS POSTAGE PAID AT WASHINGTON, D. C., AND ELSEWHERE. POSTMASTER: SEND ADDRESS CHANGES TO NATIONAL GEOGRAPHIC, P. O. BOX 2174, WASHINGTON, D. C. 20013

Regardless of what you spend on your home, it's probably the biggest financial commitment you'll make in your life. So before you settle for the insurance policy your lender is recommending, it's a good idea to get some straight answers to questions about that coverage. Does it guarantee full replacement of your home no matter what the cost? Does it offer a guarantee of the workmanship?* Will it replace your belongings without depreciation? These are all things you deserve to know before you buy. And that's where an Allstate agent can help. We're just a phone call away, and we can even provide the coverage you need on the spot. So call us for answers and prices before you close. We think you'll find both reassuring. Straight talk before closing. Another reason — You're In Good Hands With Allstate.®

A member of the Sears Financial Network

Allstate®
You're in good hands.

*Available in most areas.

Being American helps us see Europe from a special point of view.

Our Fly AAway Vacations℠ have been created with American visitors in mind.

For one, we've made getting to Europe easy. *Systemwide, we fly to nine European cities, including London, Paris and Frankfurt. Our new nonstop service from Dallas/Fort Worth to Madrid begins May 26.*

Second, we've designed these vacation package tours the way Americans like to travel. We've picked hotels that give you the flavor of Europe while providing real value for your money.

We Americans have always liked making up our own minds. We have tours by escorted motorcoach or your own rental car. *And land packages in Paris that start as low as $299* per* person, double occupancy.

Another advantage of our Fly AAway Vacations is they are at a set U.S. price. You need not worry about changes in European currency.

Then there's our Fly AAway Vacations Warranty. It's your assurance that American stands behind your Fly AAway Vacations.

You'll find all the details of our Warranty and of our European Fly AAway Vacations in two free color brochures. Just call your Travel Agent or American toll-free at *(800) 433-7300* to get yours.

***Restrictions:** Price is per person based on double occupancy for 6 nights. Valid 5/26/88-10/31/88. Price is subject to change without notice and does not include air fare, taxes or surcharges. Package requires 30-day advance purchase and reservations. Hotel subject to availability on certain dates. Some new services subject to foreign government approval. Warranty details available upon request. (IT8AA1*FTP96N)

AmericanAirlines

Something special to Europe

It lowers the s

Can a car quiet the wind? In a sense, that is precisely what the new Honda Accord LXi is designed to do.

The shape is aerodynamic. Clean all around. Windshield, windows and door handles are flush. Headlights are retractable.

The stance is low, over a newly refined double wishbone suspension system. Front and rear stabilizer bars are now larger. Stronger. So handling is more responsive.

Overall, the design provides an effective sound barrier against wind and road noise. And while you may be traveling on earth at something less than mach speed, you'll enjoy the simple comfort of quiet.

The experts at *Motor Trend* concur.

"Cruising the high-banked oval at top speed, passengers. . .carried on hushed

ound of speed.

conversation in a dead-flat acoustic environment. Wind noise was minimal and road noise was dampened effectively."

In the cockpit, with your foot pushing the accelerator, you'll find something else to enjoy. A new, 120 horsepower, fuel-injected engine with 9% more takeoff power.

And while air conditioning is standard, there's also a power-operated Moonroof. It has its own wind-deflecting device.

Will the Honda Accord, a car considered to be the standard by which other four-door sedans are measured, ever stop getting better? If you ask the engineers at Honda, the stratosphere's the limit.

HONDA

The Accord LXi

Turning rails into trails

PICK ANY SUNNY DAY in spring, and you'll find northern Virginians relaxing in a most unusual park. Only a hundred feet wide, it stretches 44 miles from the suburbs of Washington, D. C., to the foothills of the Blue Ridge.

Called the Washington and Old Dominion Railroad Regional Park (right), this narrow ribbon of open space was created in 1978 from the railway's abandoned right-of-way.

Bicyclists love the park because it provides a continuous, paved corridor through town and countryside. Equestrians appreciate its separate horse path, joggers its refreshing scenery. Cross-country skiers take to the trail after snow has driven everyone else away.

About a million people a year spend some time in the park, making it the busiest converted rail trail in the United States.

The ingenuity of the basic concept—to create a linear park from an unused railroad—has always impressed me. Only recently, during my tenure as vice chairman of the President's Commission on Americans Outdoors, did I discover how extensively the idea has caught on. There are now nearly 150 such rail trails in 27 states, with an equal number in planning stages.

Other nations are also getting into the act. In Great Britain, nearly a dozen railroads have been similarly converted, as has part of an old logging line near Victoria, British Columbia.

Each trail has a different character. Some, like the W&OD, are mainly suburban, serving local residents. Seattle's 12-mile-long Burke-Gilman Trail is a popular commuting route for students bicycling to the University of Washington.

Other trails are distinctly rural, such as the Elroy-Sparta Trail in Wisconsin, which runs through 32 miles of rolling hills, railroad trestles, and dark tunnels. Campgrounds, bed-and-breakfast inns, restaurants, and bike-repair shops have sprung up along the trail to serve 50,000 vacationers a year.

BOB ROGAN OF HERNDON, VIRGINIA, TAKES HIS DOG MAGGIE FOR A STROLL ON THE WASHINGTON AND OLD DOMINION RAILROAD REGIONAL PARK TRAIL. PHOTOGRAPH BY LIDA MYUNAJLUK.

What makes these trails possible is the fact that for decades America's rail system has been shrinking. In 1916 there were 270,000 miles of railway. By 1986 there were only 140,000. The nation's railroads abandon about 3,000 miles a year. Changing rails into trails turns these losses into gains.

And yet only a fraction of the abandoned railroads are converted to this use. Most are consumed by highways, agriculture, or unplanned development. Private groups or public agencies seeking to create trails face difficult problems, such as resolving disputes over ownership of the rights-of-way; raising money to buy the land; coordinating planning among different political jurisdictions; and winning the support of adjacent property owners. Thus far, only one of every five attempts to create rail trails has succeeded.

As with the W&OD park, however, the effort is well worth it. Property values near suburban trails are often increased by their success, and new business is generated by tourists along rural trails. I believe these trails can play an important role in the creation of a new system of parklands, a vast network of linear open spaces reaching all across the country—a system that we on the President's Commission call greenways.

If you would like more information about the rails-to-trails concept, I suggest you write to the Rails-to-Trails Conservancy at Suite 300NG, 1400 16th Street N.W., Washington, D. C. 20036.

We have an opportunity to preserve a dwindling national resource of close-to-home open space. Let's not let it slip away.

Gilbert M. Grosvenor

PRESIDENT, NATIONAL GEOGRAPHIC SOCIETY

PLYMOUTH.

THE PRIDE'S INSIDE.

VOYAGER. THE

- The only minivans with a 7/70 Protection Plan.*
- Versatile seating for 5, 6, 7 or 8.**
- Up to 150 cubic feet of carrying space. More room than Ford Aerostar.
- Easy liftback design.
- Extensive use of rust-resistant galvanized steel.

- 14" steel-belted radial tires.
- Stainless steel exhaust system.

PLYMOUTH GRAND VOYAGER LE

*J.D. Power and Assoc., 1987 Compact Truck CSI/customer satisfaction with overall product quality and dealer service on 1986 models. †Protects engine and powertrain for 7 years or 70,000 miles and outer body rust-through for 7 years or 100,000 miles. See limited warranty at dealer. Restrictions apply. **Seating for 8 available only on Grand Voyager SE with 3.0L engine, auto. trans. and front bench seat. ‡With optional heavy-duty trailer towing package.

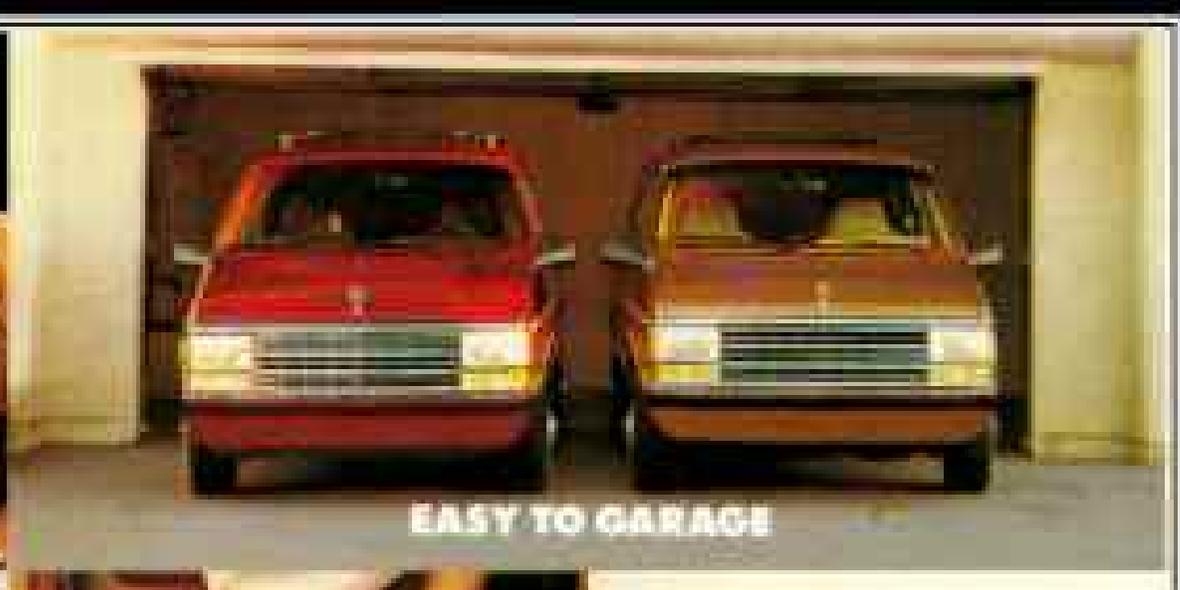
PRIDE'S INSIDE.

NO. 1 IN OWNER SATISFACTION.* ONLY PLYMOUTH VOYAGER SERIES HAS FRONT-WHEEL DRIVE, CHOICE OF SIZES AND ENGINES.

Plymouth
Division of Chrysler Motors

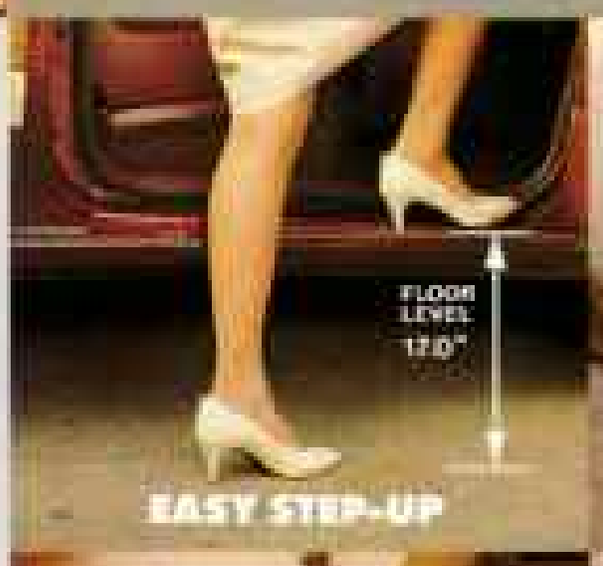
PLYMOUTH VOYAGER. THE PRIDE'S INSIDE.

NEW SPECIAL VALUE PACKAGE GIVES YOU AUTOMATIC TRANSMISSION AT NO EXTRA CHARGE WITH A 2.5 LITER ENGINE, A SAVINGS OF $549.††

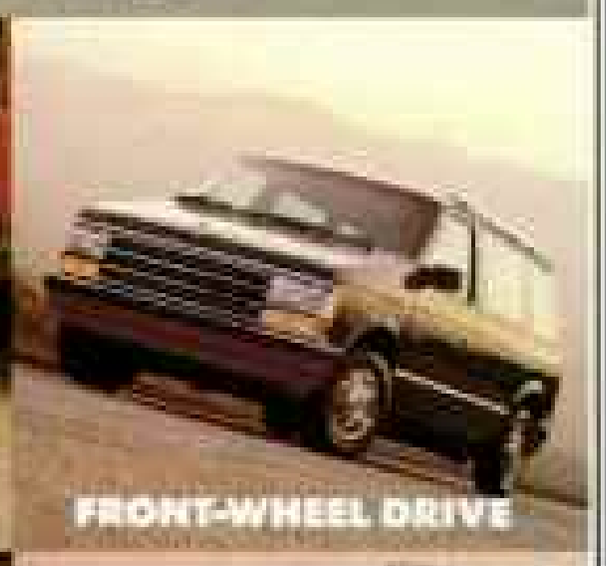


PLYMOUTH VOYAGER

PLYMOUTH GRAND VOYAGER



EASY STEP-UP



FRONT-WHEEL DRIVE

EASY LIFT-BACK

V-6 POWER EASY TOWING

The #1 minivan in owner satisfaction just got a lot more satisfying.° Because now Plymouth Voyager offers a value package that includes automatic transmission, air conditioning, AM/FM stereo, rear window defroster, deluxe sound insulation and more. A package that saves you $549. You also get Voyager's front-wheel drive, outstanding car-like handling, powerful 2.5 liter fuel-injected engine and Plymouth's 7-year or 70,000-mile Protection Plan.‡ The longest powertrain warranty of any minivan.

Plymouth Voyager. The Pride's Inside. Before You're Inside.

T/TO
Division of Chrysler Motors

††Based on traditional sticker prices of separately purchased options. °J.D. Power & Associates 1987 Compact Truck CSI/customer satisfaction with overall product quality and dealer service on 1986 models. BUCKLE UP FOR SAFETY

Guess who got a part in the school play. Call Ireland.

Patricia's going to be the good witch. But poor little Kevin didn't even make the chorus. Why not give them both a call, and let them tell you their own stories? With AT&T International Long Distance Service, it costs less than you'd think to stay close. So go ahead.
Reach out and touch someone.®

IRELAND		
Economy	Discount	Standard
6pm–7am	1pm–6pm	7am–1pm
$ .74	$ .92	$1.22

AVERAGE COST PER MINUTE FOR A 10 MINUTE CALL*

*Average cost per minute varies depending on the length of the call. First minute costs more, additional minutes cost less. All prices are for calls dialed direct from anywhere in the continental U.S. during the hours listed. Add 3% federal excise tax and applicable state surcharges. Call for information or if you'd like to receive an AT&T international rates brochure **1 800 874-4000**. © 1987 AT&T

AT&T
The right choice.

THE FUTURE ACCORDING TO TEMPSTAR

Install a new Tempstar air conditioning system now and your future will include years of reliable and efficient home comfort.

The Tempstar line is the ultimate in product reliability — destined to deliver years of trouble-free performance. Plus, the highly-efficient cooling capability could even show substantial savings on your electric bills!

We spent five years and millions on design, while we automated and computerized our factory to bring reliability and efficiency to the highest level.

To assure years of care-free operation, we offer the H.E.L.P. (Homeowners Extended Labor and Parts) program which covers any repair cost for FIVE FULL YEARS.

Tempstar air conditioning systems are made the way all systems will be some day. You'll be glad you included one in your future.

TEMPSTAR®
Heating and Cooling Products

Rely on the Star

How To Find Your Tempstar Dealer: For the name of the Tempstar dealer nearest you, look for the Tempstar or Whirlpool brand heating and cooling products dealer in the Yellow Pages of phone toll free 1-800-447-2882.

Whirlpool

1-800-447-2882

THEY ALL PINNED THEIR HOPES ON PEACE.

They were all fighters.

The conservatives fought with the liberals. The Democrats fought with the Republicans. The Bull Moosers fought with everybody.

They fought for different policies. But for the same principles. For freedom. And the freedom to live in peace.

Americans are still fighting for those principles today. And working for them too.

That's why every day more than 100,000 Americans work at General Dynamics to supply America's fighting men and women with the best weapon systems in the world.

They are working for peace. And for peace of mind.

GENERAL DYNAMICS

A Strong Company For A Strong Country

We're showing this
We'll only have 90 t

There simply won't be enough 1988 Cutlass Supremes to go around.

The problem is that when cars are built this well, there just isn't any way to crank out a million of them overnight.

For example, engineers spent the past five years just making sure the first one would be as good as it could be.

They evaluated every major car in the world, took apart the best, and examined them piece by piece to determine exactly how to better each one.

They set up an assembly line just for practice, and built Cutlass Supremes on it to find better ways to build them.

Why, they won't even

GM 1-2-1 QUALITY COMMITMENT PLAN

Let's get it together... buckle up.

See your Oldsmobile dealer for the terms and conditions of this limited warranty.

to 174 million people. housand cars. Hurry.

allow us initially to sell the first 3,000 built. They're going to test them over and over again, to make sure nothing goes wrong when yours is built.

Unfortunately, making cars this good doesn't make enough to go around.

So if you want to be among the first 90,000 on your block to own the all new 1988 Cutlass Supreme, better get on down to your Oldsmobile dealer for a test drive.

And hurry.

OLDSMOBILE QUALITY
CUTLASS SUPREME

Harbormaster™

Harbormaster™ by Bausch & Lomb.

This limited edition, exquisite solid brass telescope combines 18th century craftsmanship with 20th century state-of-the-art optical expertise. Equipped with 35 power high resolution optics, the Harbormaster provides quality viewing in an elegant, decorator design.
$3400 Suggested Retail

- Numbered Limited Edition
- 35 x 76mm • 50" High • 52" Tube

BAUSCH & LOMB

Call 800-423-3537 for information and a dealer near you.

THE BEST CARDIOVASCULAR EXERCISER

NordicTrack

Bill Koch
Olympic Silver Medalist

Scientific Proof

In tests of exercise efficiency at a major university, NordicTrack burned more calories and provided a greater cardiovascular workout than an exercise bike and a rowing machine. And a healthy cardiovascular system is your key to a full and active life.

Plus . . . Best Way to Lose Weight

Recent studies show that aerobic exercise is the most effective way to lose weight. No other exercise machine burns more calories than NordicTrack . . . so you can lose weight faster and keep it off without dieting.

Folds in seconds and requires only 17" × 23" floor space.

Easiest Way to the Best Workout

"NordicTrack is for everyone who wants the benefits of the world's best aerobic exercise, cross-country skiing. Even if you've never skied (and never plan to), in a few minutes you'll be 'tracking.' The smooth, rhythmic motion used while on the NordicTrack makes exercising pleasant and easy to sustain."

Bill Koch

Call or write for FREE BROCHURE AND VIDEO

NordicTrack
141 Jonathan Blvd. No., Chaska, MN 55318
Call Toll-FREE 1-800-328-5888
In Minnesota 1-612-448-6987, In Canada 1-800-433-9582

☐ Please send free brochure
☐ Also free videotape ☐ VHS ☐ BETA

Name _____
Street _____
City _____ State _____ Zip _____

24568

© 1988 NordicTrack

COOL THE SUN

A cool shaded home and a searing landscape may seem worlds apart, but the only difference between the two are trees... Conservation Trees that can turn a desert into a cooling oasis.

Thanks to trees, we can cool the rays of the sun. When trees shade our homes, the temperature drops substantially. That means our air conditioners won't have to work so hard in the summer. We save energy, and money as well.

Conservation Trees do a whole lot more. Planted on steep hills, the trees' roots keep the land from washing away when it rains. And in the country, trees can be planted as shelterbelts keeping the soil from blowing away.

Find out how Conservation Trees can help you. For your free brochure, write: Conservation Trees, The National Arbor Day Foundation, 100 Arbor Avenue, Nebraska City, NE 68410.

conservation trees

When you think about it, this statement makes a lot of sense.

No matter where, when, or under what circumstances death may occur, there are needs that must be met — for the bereaved family; their friends; their close circle in the community.

The funeral helps meet those needs. It helps those who grieve accept the reality of death. They know it happened. But a part of their mind rejects it, runs away from it.

The funeral takes them gently by the shoulders and turns them to face it. And having faced it, having viewed it, things are easier.

It is truly a unique moment of sharing... for the family...for friends...for society.

We will be glad to furnish you a free copy of Clark's informative "My Duty" booklet. It answers in advance many of the questions you are likely to face when you are the one who must take charge. You may receive a copy, without cost, by writing to:

CLARK
metal grave vaults

The Clark Grave Vault Company
Dept. NG-588, Columbus, Ohio 43201

It's not surprising that one out of four pharmaceuticals comes from tropical forests. Or that an estimated 1,400 tropical plants, like the rosy periwinkle, have promising anti-cancer properties. After all, as home to half of the world's plant and animal species, these forests are a vast biochemical warehouse.

What is surprising is that the human race is destroying this living resource at an alarming pace.

Each day, 74,000 forested acres are cleared, pushing untold numbers of species toward extinction.

The future of medicine and agriculture, the existence of thousands of wildlife species, and the survival of hundreds of millions of people in developing countries depend on what we do now to keep the tropical forests alive.

The means of solving this problem are within our reach. Write in order to find out how you can help keep the tropical forests alive, before the reasons disappear.

Keep Tropical Forests Alive.

Tropical Forest Project, World Resources Institute, 1735 New York Avenue, N.W. Washington, D.C. 20006 / Prepared by Richardson, Myers & Donofrio, Inc.

Butterflies of the World

PORCELAIN SCULPTURE COLLECTION

Fine porcelain
with delicate hand-painting.
$29.50 per sculpture.
Available on a
convenient monthly basis.

So exceptional an artist is Brian Hargreaves of Great Britain that he was commissioned to portray the gardens and butterflies of Buckingham Palace for Queen Elizabeth II. Now he brings his talent to the design of an exclusive collection of sculptures: *The Butterflies of the World.*

This intriguing new collection makes it possible for you to have a garden of butterflies and flowers in your home all year long! Fifteen delightful butterflies in their own natural floral settings–representing all fifteen butterfly families in nature's kingdom.

You'll be able to display this collection attractively in your home. For you will receive a beautiful *étagère* of brass and glass to hold all of the imported porcelain sculptures.

Brian Hargreaves' designs are so finely detailed that *each* delicate wing of a butterfly and *each* petal of a flower is precisely as you see it in nature. From the Monarch Butterfly with its bright orange coloring...to the boldly-striped Zebra Longwing...to the spectacular Malachite with emerald-shaped wings. The variety of colors is astonishing too –every shade and tone nature has given these charming creatures of flight.

To acquire the collection, please mail your application by June 15, 1988.

Actual size.

Brass and glass étagère provided at no additional charge.

Subscription Application

Please mail by June 15, 1988.

The Franklin Mint
Franklin Center, Pennsylvania 19091

Limit of one collection per person.

Please enter my subscription for The Butterflies of the World Porcelain Sculpture Collection by Brian Hargreaves, consisting of fifteen miniature sculptures to be crafted in fine porcelain with delicate hand-painting. The sculptures will be sent to me at the rate of one per month.

I need send no money now. Please bill me $29.50* for each sculpture in advance of shipment. I will also receive a brass and glass étagère at no additional charge.

*Plus my state sales tax and $1.95 for shipping and handling.

Signature _____

ALL APPLICATIONS ARE SUBJECT TO ACCEPTANCE.

Mr./Mrs./Miss _____

PLEASE PRINT CLEARLY

Address _____

City, State, Zip _____

85387-300

Members Forum

Centennial

The first 43 pages of the January 1988 issue were especially great. Hard work, leadership, and mostly pride show every month. The Society has won accolades from around the world, but the bottom line is taking readers personally on trips around the world that we would never experience otherwise. It's greatly appreciated.

JIM DAVIS
Viburnum, Missouri

Three things that have been part of my life for more than 70 years celebrated their 100th anniversaries in 1987 and 1988: Log Cabin syrup, *Sports Afield*, and NATIONAL GEOGRAPHIC.

ROBIE K. BEAN
Santa Cruz, California

The Geological Society of America is also at the century mark in 1988.

HAROLD SUGDEN
Bakersfield, California

Those Electrifying 1880s

Readers are advised that a central founder of our Society, Maj. John Wesley Powell, is the "daring conqueror of the formerly unknown Colorado River." Your own files record ancient Indian settlements along the Colorado; these early peoples were its first "conquerors." In 1540 García López de Cárdenas became the first European to know the Colorado and the Grand Canyon. In 1583 de Espejo and in 1604 Juan de Oñate—Spanish colonizer of New Mexico—also explored along the Colorado.

AMBASSADOR FRANK V. ORTIZ
Santa Fe, New Mexico

Powell in 1869 was the first to run the river through the Grand Canyon by boat.

Discovering America

I enjoyed the article "Discovering America" by Małgorzata Niezabitowska (January 1988), but for her statement that "free access to guns is a disturbing symbol of America to us. In Poland, ownership of guns is strictly controlled." The Texas Supreme Court in an 1859 decision said the people cannot be oppressed and enslaved who are not first disarmed. Is it not a pity Poland does not have a second amendment.

PETER R. C. BIRD
Albuquerque, New Mexico

More than 80 letters expressed similar sentiments. The second amendment to the U. S. Constitution says: "A well regulated Militia, being necessary to the security of a free State, the right of the people to keep and bear Arms, shall not be infringed." Its purpose was to prevent Congress from disarming state militias.

The article was fascinating because you dealt with a fascinating nation from an exceptional viewpoint.

FELIX HUBER
Elgg, Switzerland

I appreciate the nonfocus on the big cities as exemplifying America. We have lived in the middle of dairy farming for ten years and have been delighted to see that there is a lot more than "life in the fast lane." Community interdependence, funeral suppers, the Ladies Aid, where we gather to tie quilts—this way of life did not die in the 1940s. Małgorzata and Tomasz sound like people we would all love to know.

JUDITH AVEDISIAN
Dansville, New York

Upon graduation from college last May many friends wanted to head for Europe or Australia for summer travel. Instead, I made a ten-week tour of the United States. For $1,500 I experienced the Great Smoky Mountains, white-water rafting down the Rio Grande, a trip to the bottom of the Grand Canyon, wine tasting in Napa Valley, beautiful Crater Lake in Oregon, and a 12-day ferry and camping sensation in Alaska that left me breathless. Culturally and pictorially America is beautiful. Every American should take the opportunity to see our country—or read the article by Niezabitowska and Tomaszewski.

PATRICK CORRENTY
Darien, Connecticut

Obviously we have problems in this country. But to suggest that a white supremacist is a serious political figure or that junk dealing is a normal way of life is to use the exception and make it appear to be the rule. But at least Americans had an example of mainstream Polish journalism.

ED AND MAŁGORZATA STAMM
Lawrence, Kansas

Poland

I have read a number of excellent articles by Tad Szulc and have never failed to be impressed. His professionalism shines in the informative update on Poland.

JANE ZAYATZ
Passaic, New Jersey

Writing of Stalin's robbery of eastern Polish lands, writer Szulc comments that "Stalin compensated Poland by awarding it German

lands where Poles had lived for centuries." Silesia, eastern Brandenburg, central and eastern Pomerania, East Prussia and even Danzig, present-day Gdańsk, had overwhelmingly ethnic German populations for centuries. Even those that had Polish majorities voted during 1920-21 plebiscites in favor of remaining within the German state. The forced expulsion of ethnic Germans from these lands was a crime.

JOHN STRANG
Dorchester, Massachusetts

In 1939 Hitler did not demand that "Poland give up Gdańsk." It had been separated from the Deutsches Reich since 1919 as a free state with a high commissioner of the League of Nations. It was nevertheless a German city where I was born and lived as a German until I became a displaced person in 1945.

SIEGFRIED H. LUCKMANN
West Berlin

The report from Poland is a masterpiece of writing, but most of all it is honest and real. Now I wonder if *glasnost* will be more than an overused phrase, and if the Polish censors will let the Poles read about Katyń, the Soviet invasion or annexation, and other events not found in the history books while I was there.

MAREK URBANEK
Phoenix, Arizona

Members in Poland tell us they received their copies.

It may be of interest to know that Americans took part in the 1944 Warsaw Uprising. The 390th Bomber and other Eighth Air Force Groups in England were alerted to air-drop medicine and food to Polish freedom fighters within Warsaw. Inclement weather delayed the mission several days, and German intelligence moved in fighter planes and flak batteries. These caused heavy casualties. More casualties resulted when the groups swung over Soviet-occupied territory across the Vistula River and Soviet gunners joined the turkey shoot. Our dead were buried in the military cemetery at Poltava, Ukraine; they lie there still.

JOHN DUDAR
Wellsville, New York

Geographic Education

As one who wishes to become a geography teacher, I have studied the history of geographic education and found that the concerns the Society is expressing date back at least to 1813. The history of geographic education in the U. S. is littered with the hulks of programs similar to those you are promoting, most recently the High School Geography Project (1961-1970). Since the state of geographic education continues to be deplorable, past programs must be judged as failures.

What will be done to ensure that history does not repeat itself?

WILLIAM J. WRIGHT
Stafford, Texas

The National Geographic Society Education Foundation, with an initial Society gift of 20 million dollars, will concentrate on teaching teachers, an approach found very effective thus far.

I was glad to learn that a Senate subcommittee was aware of the need for improved education in geography and history (January 1988), but all the committees of Congress won't help unless we're willing to help ourselves. The family must assume some responsibility and burden of teaching. Mine has started by keeping a world atlas next to the television's remote-control unit. For Christmas we exchanged games and books with a geographical and historical flavor, lest we forget that learning can be fun.

ARTHUR K. HUSEONICA
Virginia Beach, Virginia

Jigsaw puzzles of the U.S.A. and the world plus cookie cutters of the states have been tools I have used to try to bring the grandchildren to an awareness of geography.

EDITH L. FOLEY
Eugene, Oregon

For several years I, as a high school principal,

heard complaints from citizens that our students knew little about geography. Four years ago I recommended to our board of education making a semester of freshman geography mandatory. I expected complaints from students. The opposite occurred. They requested a second semester. It has been a huge success, and student scores in social studies have seen a marked increase.

DAVID L. BURROWS
Genoa, Illinois

Süleyman

To my surprise, I found on page 578 of the November 1987 issue a photo of my sculpture at Mohács, where Hungarians were annihilated by the Turkish army. Hungary always seems to have acted as a buffer between East and West, a role which can hardly be considered rewarding. I took great pains to depict this in my work and now feel I have made my point. Thank you for the honor.

PÁL KŐ
Budapest, Hungary

Letters should be addressed to ***Members Forum,*** *National Geographic Magazine, Box 37448, Washington, D. C. 20013, and should include sender's address and telephone number. Not all letters can be used. Those that are will often be edited and excerpted.*

WE'LL TREAT YOU WITH RESPECT, CONCERN ÁND UNDERSTANDING.

BUT DON'T WORRY, YOU'LL GET USÉD TO IT.

Let's face it.

When it comes to respect, concern and understanding, most people rank banks right up there with the phone company and the Internal Revenue Service.

So if you're a little skeptical when you see words like these in a bank ad, well, we understand.

All we ask is a chance to prove to you that, at any member of the 1st Nationwide Network, they're more than words.

They're the philosophy we built the Network on. And before any bank gets to display our sign outside their building, they have to demonstrate the right attitude inside their building.

If you'd like to check us out for yourself, we invite you to stop by any of the independent financial institutions that make up the 1st Nationwide Network. A network which, at present, covers 38 states and has combined assets of over $31 billion. Or call us toll free at (800) 826-1092 for the member branch nearest you.

1ST NATIONWIDE NETWORK

NATIONAL GEOGRAPHIC MAGAZINE

NATIONAL GEOGRAPHIC SOCIETY

"For the increase and diffusion of geographic knowledge"

THE NATIONAL GEOGRAPHIC SOCIETY is chartered in Washington, D. C., as a nonprofit scientific and educational organization. Since 1890 the Society has supported more than 3,400 explorations and research projects, adding immeasurably to man's knowledge of earth, sea, and sky.

WHERE TO GET A LITTLE RESPECT, CONCERN AND UNDERSTANDING IN THIS COUNTRY.

ARIZONA

1ST NATIONWIDE BANK
A FEDERAL SAVINGS BANK

CALIFORNIA

CALIFORNIA PROFESSIONAL
SAVINGS & LOAN
1ST NATIONWIDE BANK, FSB
FIRST NETWORK
SAVINGS BANK
UNIVERSITY SAVINGS BANK

CONNECTICUT

CITY SAVINGS BANK
OF MERIDEN

COLORADO

1ST NATIONWIDE BANK, FSB

DELAWARE

DELAWARE SAVINGS BANK

FLORIDA

FIRST FEDERAL OF PERRY
1ST NATIONWIDE BANK, FSB

GEORGIA

FIRST FEDERAL
of COLUMBUS

HAWAII

1ST NATIONWIDE BANK, FSB

IDAHO

AMERICAN SAVINGS

ILLINOIS

1ST NATIONWIDE BANK, FSB
PEORIA SAVINGS & LOAN
SECURITY FEDERAL
of SPRINGFIELD
SUBURBAN FEDERAL
SAVINGS of FLOSSMOOR

INDIANA

AMERICAN SAVINGS, FSB

IOWA

HAWKEYE FEDERAL
SAVINGS BANK OF BOONE

KANSAS

RAILROAD SAVINGS & LOAN

KENTUCKY

1ST NATIONWIDE BANK, FSB

LOUISIANA

CAPITAL UNION SAVINGS

MARYLAND

1ST NATIONWIDE BANK, FSB
FIRST SHORE FEDERAL
HOME FEDERAL
SAVINGS BANK

MASSACHUSETTS

BAY STATE SAVINGS BANK
FIRST MUTUAL of BOSTON
WARREN FIVE CENTS
SAVINGS BANK

MICHIGAN

D&N SAVINGS BANK
1ST NATIONWIDE BANK, FSB

MINNESOTA

METROPOLITAN FEDERAL
BANK

MISSISSIPPI

REPUBLIC BANK for SAVINGS

MISSOURI

1ST NATIONWIDE BANK, FSB

NEVADA

FRONTIER SAVINGS
ASSOCIATION

NEW HAMPSHIRE

FIRST NORTHERN BANK
FORTUNE GUARANTY
SAVINGS BANK

NEW JERSEY

AXIA FEDERAL
SAVINGS BANK
FAMILY FIRST FEDERAL
SAVINGS BANK
FELLOWSHIP SAVINGS
FIRST AMERICAN SAVINGS
NUTLEY SAVINGS &
LOAN ASSOCIATION
THE PROVIDENT
SAVINGS BANK

NEW MEXICO

NEW MEXICO FEDERAL

NEW YORK

1ST NATIONWIDE BANK, FSB
ELMIRA SAVINGS & LOAN, FA

NORTH CAROLINA

PREFERRED SAVINGS BANK

NORTH DAKOTA

METROPOLITAN FEDERAL
BANK

NORTHWESTERN FEDERAL
SAVINGS & LOAN

OHIO

1ST NATIONWIDE BANK, FSB
THE FIRST SAVINGS
& LOAN COMPANY

OKLAHOMA

AMERICAN HOME SAVINGS

PENNSYLVANIA

CITIZENS SAVINGS
ASSOCIATION
EAST STROUDSBURG
SAVINGS ASSOCIATION
ELMWOOD FEDERAL
SAVINGS BANK
FIRST AMERICAN SAVINGS
1ST NATIONWIDE BANK, FSB
FOUNDERS FEDERAL
SAVINGS & LOAN
ASSOCIATION
SELLERSVILLE SAVINGS
& LOAN ASSOCIATION
SPRING HILL SAVINGS
& LOAN ASSOCIATION OF
PITTSBURGH
STAR SAVINGS &
LOAN ASSOCIATION

SOUTH CAROLINA

FIRST BANK of ROCK HILL
NEWBERRY FEDERAL
SAVINGS BANK

SOUTH DAKOTA

METROPOLITAN FEDERAL
BANK

TENNESSEE

MORRISTOWN FEDERAL
TWIN CITY FEDERAL SAVINGS
& LOAN ASSOCIATION

UTAH

UNITED SAVINGS & LOAN

VIRGINIA

1ST NATIONWIDE BANK, FSB
NEWPORT NEWS
SAVINGS BANK

WASHINGTON

AMERICAN SAVINGS BANK
MT BAKER BANK

WISCONSIN

WEST ALLIS
SAVINGS & LOAN

1ST NATIONWIDE NETWORK

TOYOTA COROLLA

A NEW DIMENSION OF POWER.
With a 22% horsepower boost, the efficient* 16-valve engine threads passengers effortlessly through the traffic of the ordinary.

A NEW DIMENSION WORTH LOOKING INTO.
View the road from a position of authority in a 6-way adjustable driver's seat. And enjoy the ease of an instrumentation panel nestled close for fingertip control.

A NEW DIMENSION OF STYLE AND COMFORT.

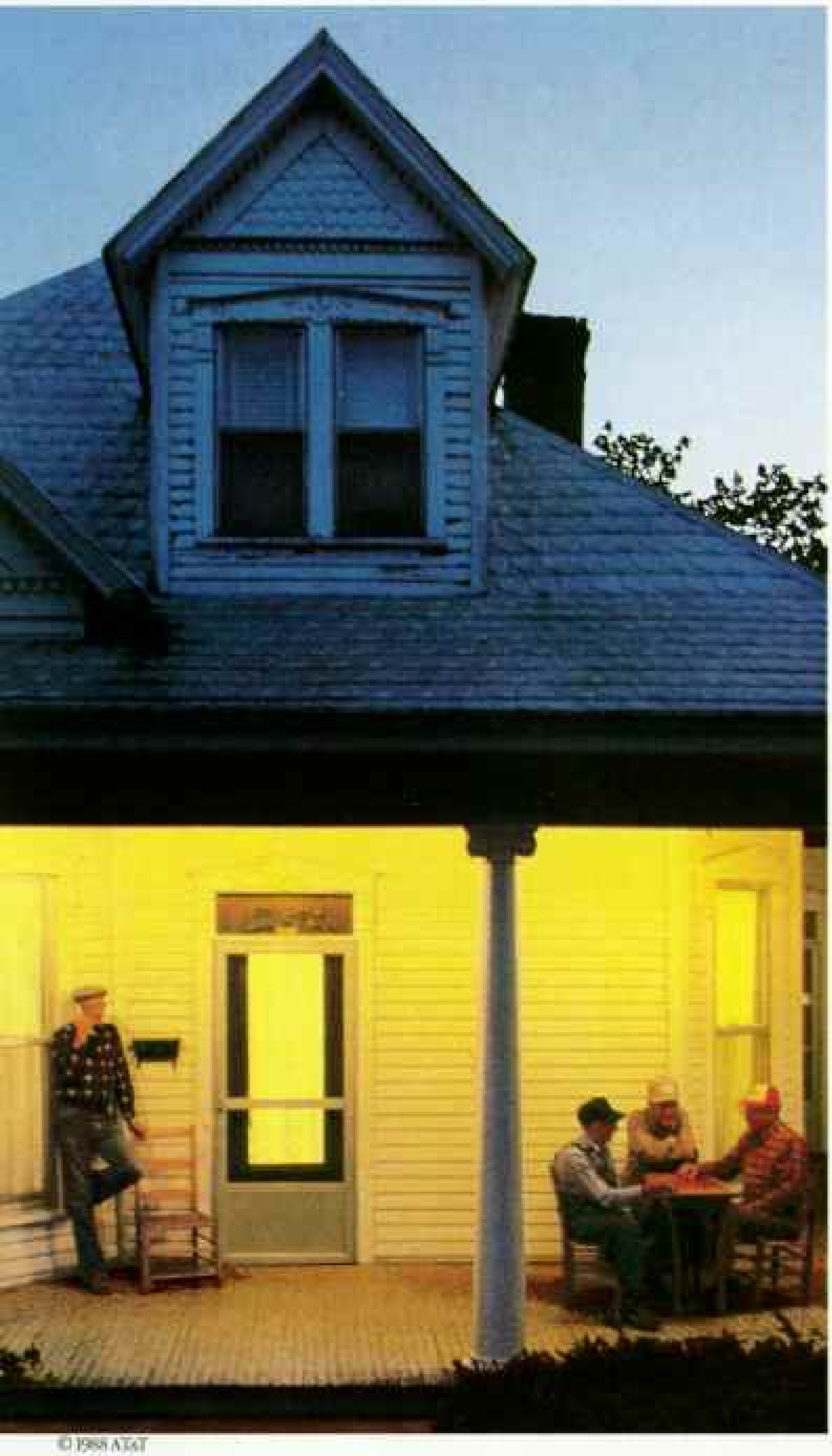
The depth and beauty of the new 1988 Corolla LE Sedan is not an illusion. It's a reality. Refined chassis engineering plus front-wheel drive offers the superiority of a quieter ride and better handling at all speeds. A new dimension of exterior craftsmanship complements a new dimension of interior finesse. Five adults ride in soft-cloth seats that cradle with comfort. Traditional Toyota Quality with a new dimension of style and comfort. The 1988 Corolla LE Sedan is the one car you must see—when you're shopping for a car you'll be proud to be seen in. For more information on the 1988 Toyota Corollas, call 1-800-331-4331—Mon.–Fri. 9 a.m. to 9 p.m., EST.

Get More From Life . . . Buckle Up!

*EPA estimated 30 city/35 highway MPG for Corolla Sedan with 5-speed manual overdrive transmission.

TOYOTA QUALITY
WHO COULD ASK FOR ANYTHING MORE!

We still think there's a lot to be said for small talk.



You get more out of every long distance call on AT&T.

Whether you're just checking in with the folks back home, or checking up on a business deal, AT&T helps you make the most of every long distance call.

The unmatched capacity of the AT&T Worldwide Intelligent Network helps put your calls through twice as fast as any other company. And on the first try.

What's more, AT&T has lowered its long distance prices overall by more than 35% since 1984 (based on direct-dial, state-to-state calls).

So if you value every call, let AT&T's network and lower prices come through for you.

We're reaching further to bring your world closer.

AT&T
The right choice.

THE NEW 160-HP, FUEL-INJECTED S-10 BLAZER. NOW YOU CAN ACCELERATE YOUR ESCAPE VELOCITY.

America's most popular escape vehicle is now available with the biggest engine in its class—the 4.3 Liter Vortec V6. To make the powerful pleasures of getting away from it all in a 2- or 4-wheel-drive Chevy S-10 Blazer even more exhilarating.

You get 28% more horsepower and 50% more torque than previously available. More power to pass, more power to tow, more power to whisk you to the office, shopping or country club.

Or, with the flick of a single lever, you can feel the freedom of dashing across countrysides, fording streams, climbing mountains, plowing through blizzards, humming down rain-slicked roads. Because the 4x4 Chevy S-10 Blazer comes complete with patented Insta-Trac, to let you shift from freewheeling 2WD to 4WD High and back at any speed.

Test drive Chevy S-10 Blazer, now with new available fuel-injected Vortec V6 power. It'll make your palms itch and your heart beat faster.

Very, very quickly.

GM 6000 QUALITY COMMITMENT PLAN Let's get it together. buckle up

See your Chevy dealer for terms and conditions of the limited warranty.

Best-backed Blazers ever. 6-year/60,000-mile powertrain warranty protection and 6 years or 100,000 miles of body-rust-through protection. Solid proof of the quality built into every new Chevy S-10 Blazer.

THE *Heartbeat*

OF AMERICA TODAY'S CHEVY TRUCK

CRIME FIGHTER, AGE SIX.

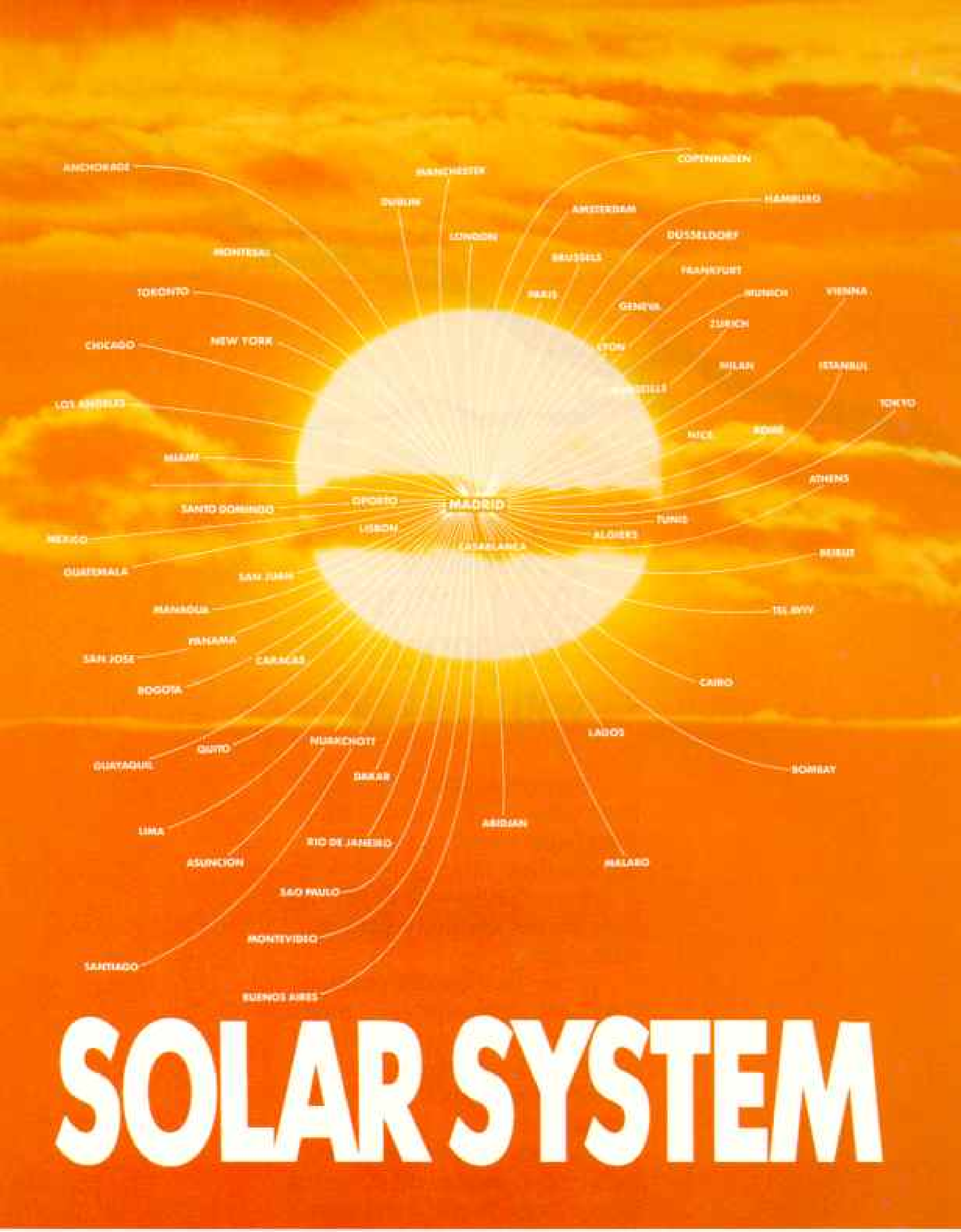
In cities, suburbs and rural communities all across the country, persons involved in crime are younger than ever. And so are the victims.

Camp Fire responds to this alarming statistic with "I'm Safe and Sure," a program that combines personal safety and good citizenship, specifically structured for kindergarten and first grade children. It's just one of many Camp Fire "learning for life" programs that teach kids vital lessons in living — for today and for their future.

As kids' needs have changed, so has Camp Fire. Today, you'll find Camp Fire involved in national issues which affect boys and girls of all ages.

Support Camp Fire in your community. For more information on today's Camp Fire, write Camp Fire, Dept. E, 4601 Madison, Kansas City, MO 64112.

Camp Fire



SOLAR SYSTEM

A lesson from nature for people with cancer.

Every spring, nature teaches us a lesson of survival and renewal. At USC's Norris Cancer Hospital we understand that lesson well.

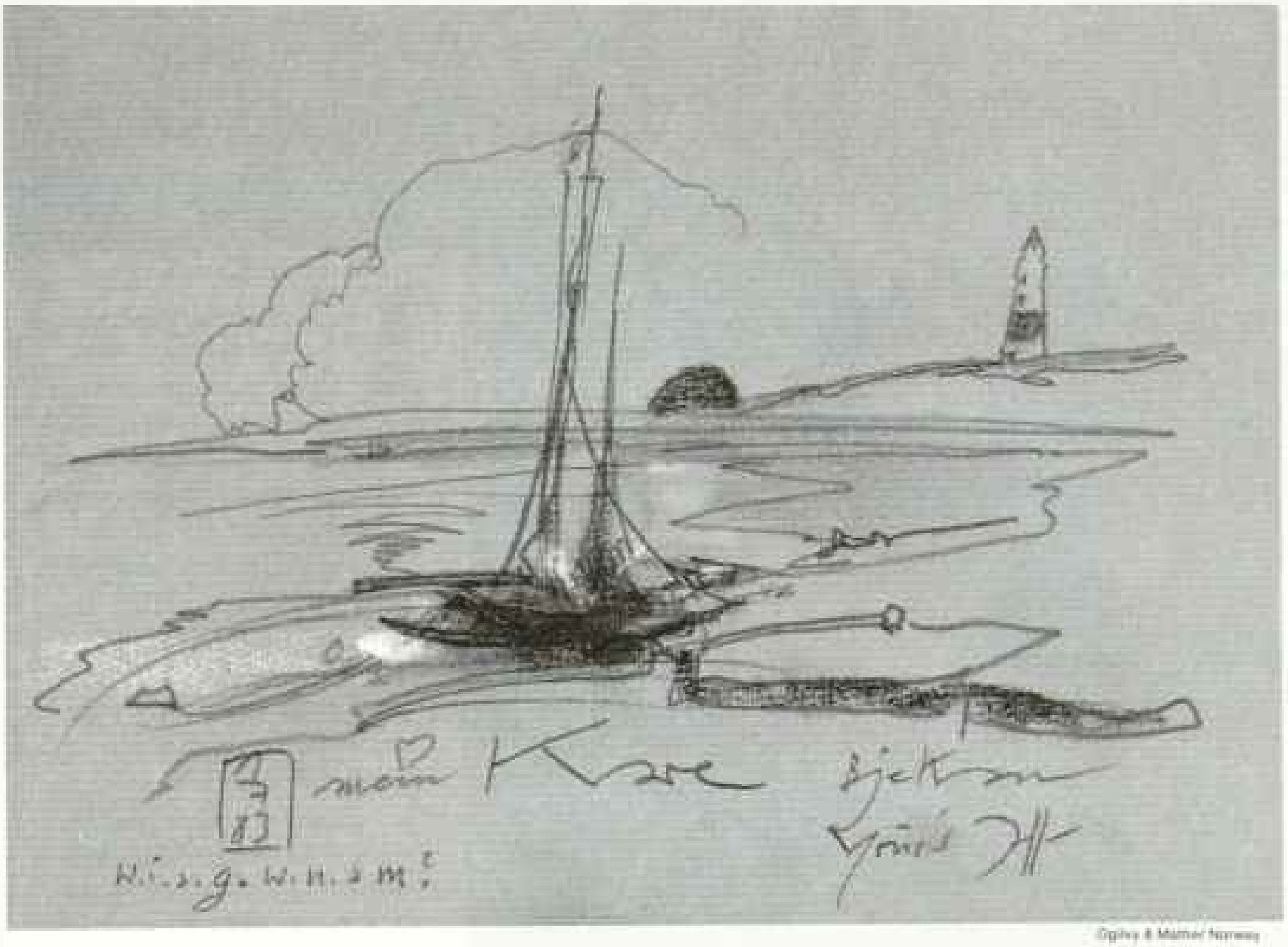
Every day, our patients are helped by teams of cancer specialists to reach for another spring.

We are one of only 20 federally designated comprehensive cancer centers. The treatments we offer are the latest available; so is our equipment. Our research in every aspect of the disease never stops.

To schedule a second opinion, or just learn more about us, call the Kenneth Norris Jr. Cancer Hospital at the University of Southern California. 1-800-5-CANCER or 1-213-CANCER-0.

USC/NORRIS
CANCER HOSPITAL

Horst Janssen's Oslo



Ogilvy & Mather Norway

Of all that Oslo has to offer, the German painter Horst Janssen has chosen to portray the calm and harmony.
Sun. Clouds. Still waters. A rocky coastline. A lighthouse. A sailboat. Is it early morning or late evening?
In Horst Janssen's Oslo, there is room for imagination. And for you.

If you want mass tourism – the crowds, the stress, the hassle – then don't send us this coupon. If you want interesting and exciting experiences in a spectacular city where the old world meets the new – then do. Oslo, at the head of the fjord, surrounded by forests and mountains. A city where you can experience the unexpected, be inspired – and feel alive. The capital of Norway. In the heart of Scandinavia.

PLEASE SEND ME MORE INFORMATION ABOUT OSLO.

Name: _____

Address: _____

City: _____

Country: _____

Noors Nationaal Verkeersbureau, Saxen Weimarlaan 58,
NL-1075 CE Amsterdam, HOLLAND.

Norwegian
Tourist Board,
20 Pall Mall,
GB-London SW1Y 5NE,
ENGLAND.

Norwegisches
Fremdenverkehrsamt,
Hermannstrasse 32,
D-2000 Hamburg 1,
BRD.

NOR/89/O

Oslo

YOU WON'T BELIEVE IT

HORST JANSSEN CHOSE TO FLY SCANDINAVIAN AIRLINES TO OSLO. SAS

SERVING 'TIME!

Tune in Sunday, May 1 . . . and discover why animals are placed behind bars as a last refuge from extinction. And on . . .

- *Sunday, May 8,* journey to Lebanon for a rare investigation of a war dependent on drug money.
- *Sunday, May 15,* pursue a saltwater crocodile on Australia's Cape York peninsula with a real-life Crocodile Dundee.
- *Sunday, May 22,* team up with the Black Baron and a one-of-a-kind flying circus of antique planes.
- *Sunday, May 29,* travel through New Hampshire and Vermont with a dedicated craftsman who repairs old-time covered bridges.

Every Sunday
9p.m. ET*on
SuperStation TBS.

NATIONAL GEOGRAPHIC EXPLORER

*And Mondays at midnight ET/9 p.m. PT and Saturdays 9 a.m. ET

On Assignment

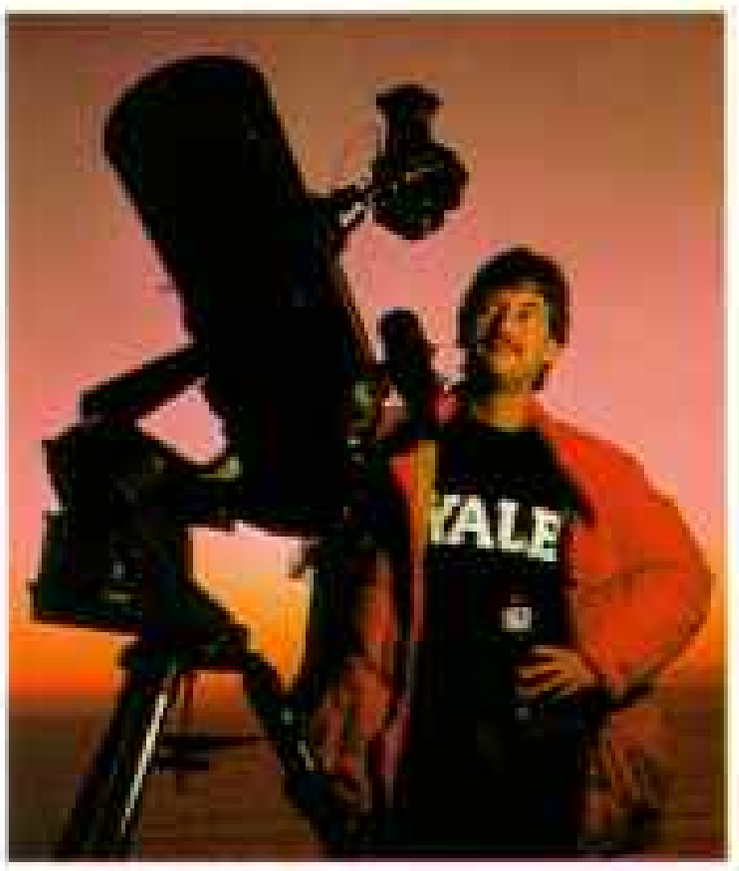
STAVE RAYNER (ABOVE); JEANNE TROMBLY, STARLIGHT (RIGHT)

LANGUAGE poses no barrier in the Arab world for Senior Writer THOMAS J. ABERCROMBIE, who speaks Arabic. In Sharjah he found a kindred bilingual spirit in Sheikh Sultan bin Muhammad al-Qasimi, a Ph.D. from Exeter University in England.

Sailing the Strait of Hormuz by dhow, performing emergency foot surgery on a Tibetan, diving on a Roman wreck—all is routine for the Minnesota-born writer-photographer. Soon after Tom joined the NATIONAL GEOGRAPHIC in 1956, he became the first civilian correspondent at the South Pole.

Of his work in some 40 lands, he says: "If a writer has the patience and enough time in a place, he or she can usually get a country to tell its own story."

WIZARD at shooting stars, ROGER H. RESSMEYER (below) made the lead picture of our supernova story by connecting a camera to a rotating eight-inch telescope—thus eliminating the blur of star trails. The 34-year-old Long Island native recalls, "After John Glenn went into orbit, I was hooked on space. I built a telescope at 11 and later studied astronomy at Yale." Ressmeyer's first photographic client was singer Grace Slick of the suitably celestial rock group Jefferson Starship.



CARY WOLINSKY

BARBARA CHMIEL WOLINSKY

HOW TO shear a sheep? First lull it to torpidity by rolling it on its rump, says photographer CARY WOLINSKY (left, with his son Yari). For a half shear he recruited a champion Australian shearer, who after many tries created the striking cutaway that leads our wool story.

Author NINA HYDE (far left) took a liking to a felt *kepenek* in western China. The shepherd's coat gave the fashion editor of the *Washington Post* renewed respect for what a garment can do: "It serves as a coat and as a house, and you don't have to worry about hemlines."