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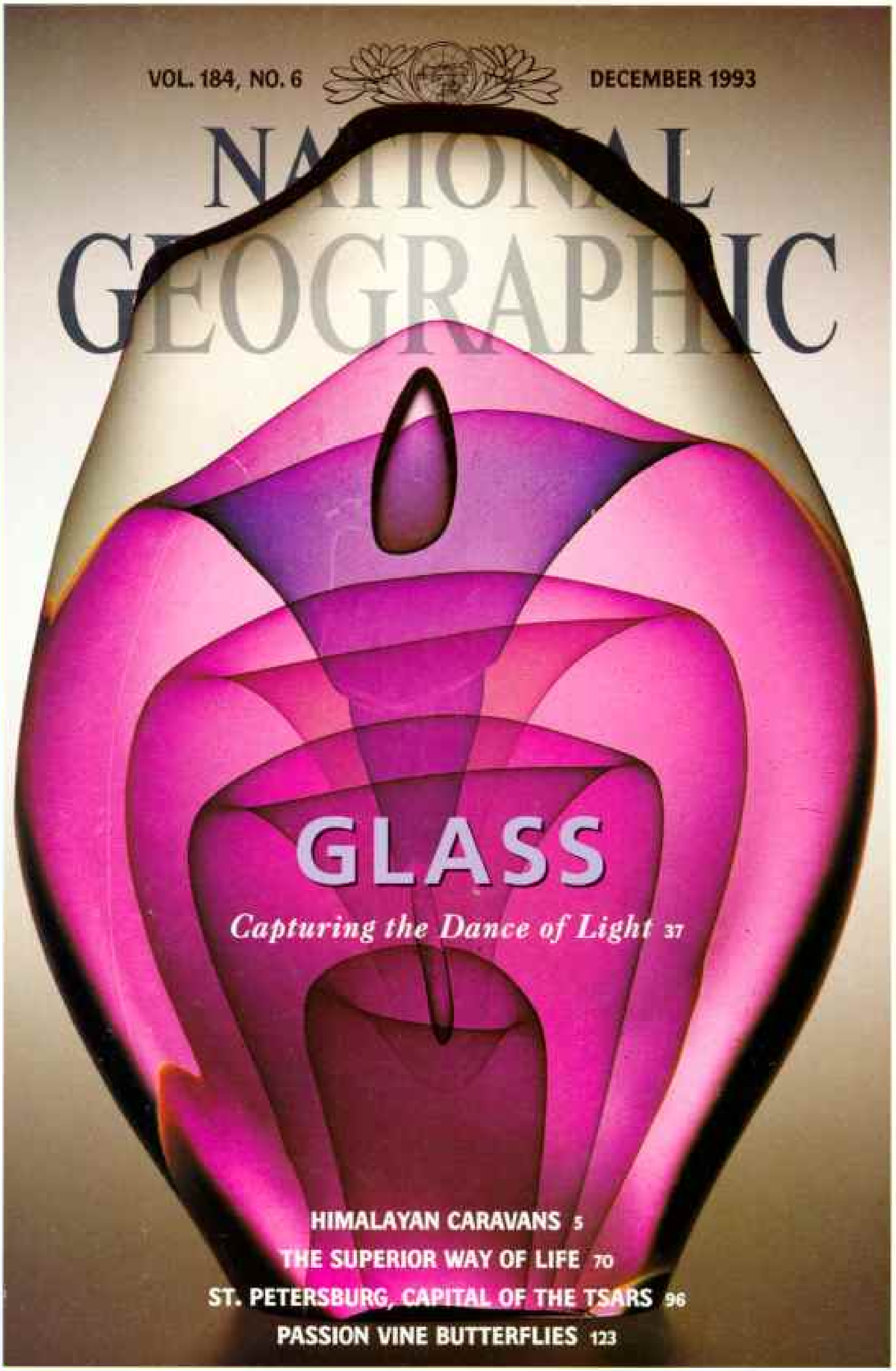

GLASS

Capturing the Dance of Light 37

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NATIONAL GEOGRAPHIC

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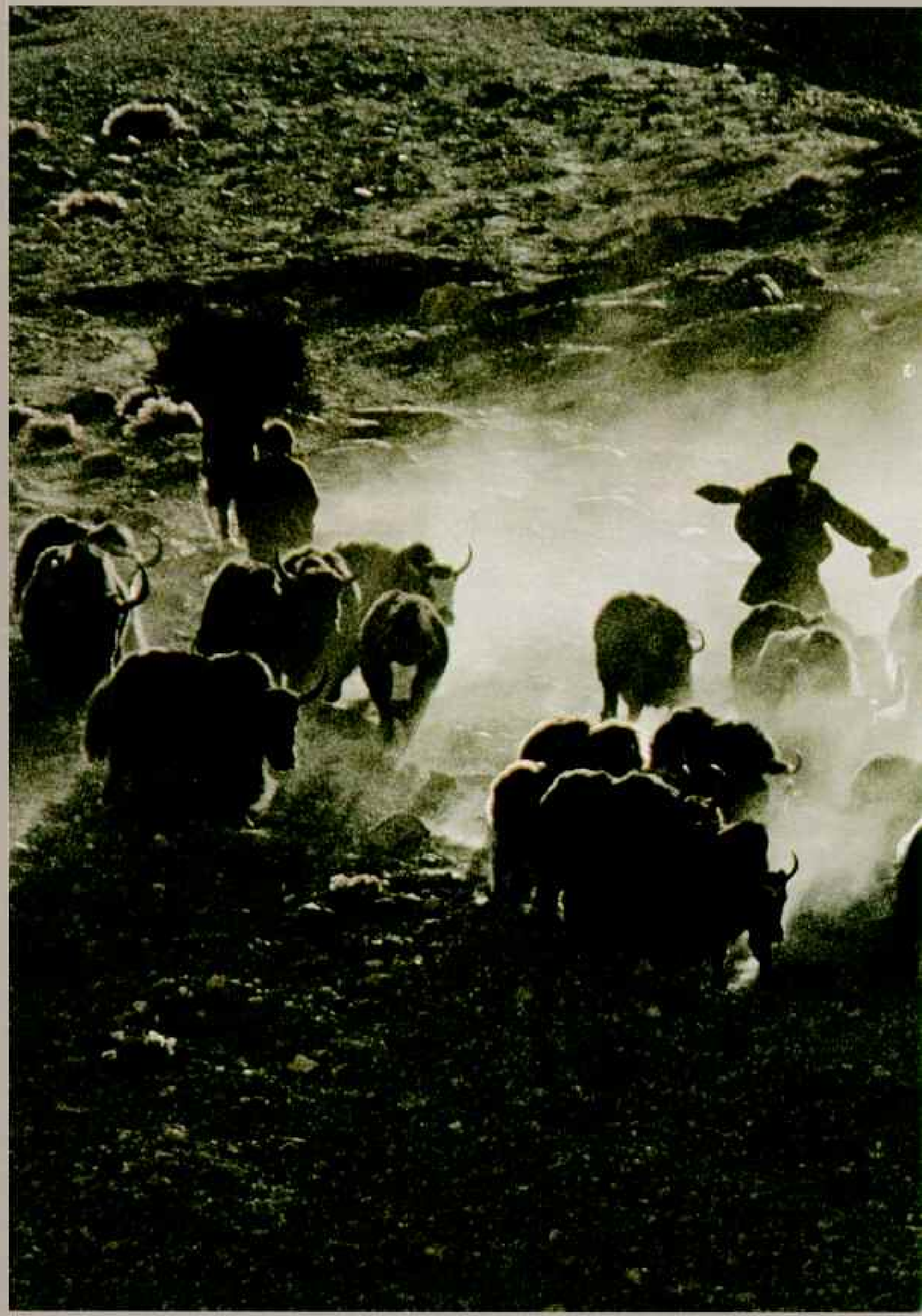
COVER: Glass becomes art in the hands of such gifted sculptors as Dominick Labino, who added minuscule measures of gold to achieve these roseate shades. Photograph by James L. Amos.

HIMALAYAN

CARAVANS

In a remote corner of the Himalaya, two distinct cultures preserve an age-old trade in life's necessities. Buddhist yak herders of Dolpo, a region in northwestern Nepal, leave their mountain home each summer to trade for salt in Tibet, then for grain in central Nepal. There they meet the Rong-pa, Hindu shepherds in need of salt, who travel the trail in caravans of their own (overleaf), led by men like Nanda Lal Thapa (above).

Article and photographs by
ERIC VALLI and DIANE SUMMERS



Dodging hoofs and horns, Dolpo caravanners drive yaks down from summer

pasture before the trip north into Tibet—first leg of an annual six-month journey.

THE PLAYERS watch Tundup's fist as he prepares to throw the dice. "Surkhang!" he yells—the name of Renzing's house—and rolls a five. He places a pebble in front of Renzing. No one disputes the call. Tundup is headman, and the gods will decide this game of chance anyway.

Strands of unruly black hair escape the plait wound around Tundup's head. His broad forehead emphasizes an intelligent and gentle face. Like the other men and women here in Saldang, a village in northwestern Nepal, he has copper skin, almond eyes, and high cheekbones that speak of a Tibetan ancestry.

Chang, a barley beer, flows. Voices break into laughter. The throw of the dice quickens. There is a festive feeling among the farmers, even though they are gambling with survival.

They are playing *chu gyen*, a game whose name means "to win water." Tundup explains: "Our lands are large, but our barley crops cannot survive with the meager rainfall. So our forefathers chose this system of distribution."

The farmers irrigate their fields from reservoirs fed by mountain streams. The water is carried to the fields through channels, but it is barely enough and must be carefully divided. Every April before plowing, the farmers gather for chu gyen. The household that wins the most points from the dice gets its share of water first. Second place comes next, and so on until the last drop is distributed. This is the order until June.

"This year Renzing's land wins, and mine may lose. Next year my fields may win and Renzing's lose. You see, over the years the dice game is very fair," Tundup says.

"And whoever is last?" I ask. "What if there is no water left for his fields?"

"If there is not enough, everybody's share is cut when we irrigate a few weeks later. That way we all share the burden."

It is a practical system for an arid land.

ERIC VALLI and DIANE SUMMERS covered daring aerial hunters in Thailand's "Nest Gatherers of Tiger Cave" (NATIONAL GEOGRAPHIC, January 1990) and "Honey Hunters of Nepal" (November 1988).

From the courtyard of Tundup's house, where the game is in progress, I look down on the dusty, terraced fields of Dolpo (map, page 13), an ethnic region within Dolpa, Nepal's largest and most remote district. Beyond the village, naked slopes that have eroded into deep gullies rise to mountain parapets dusted with snow.

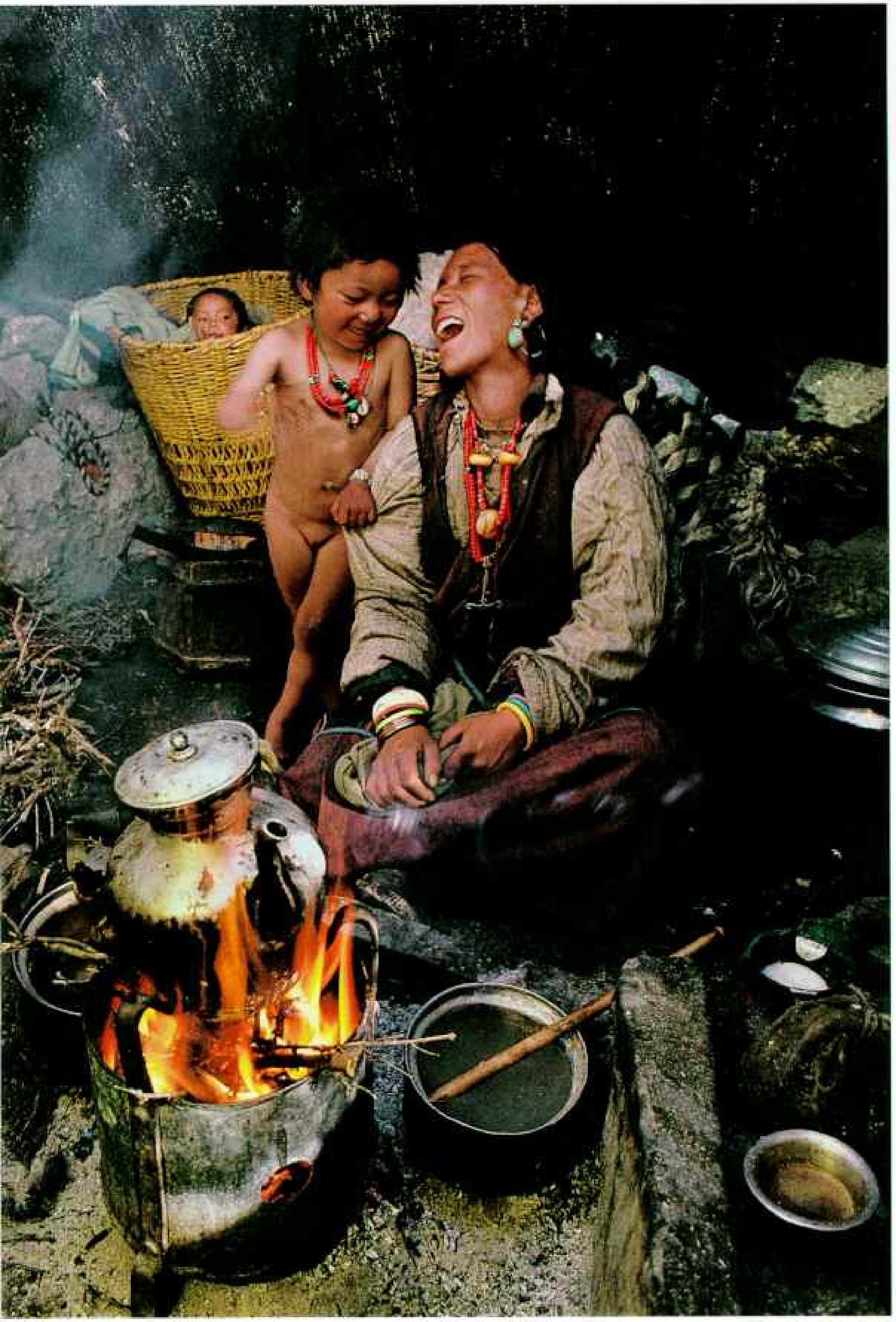
To the south lies the Himalaya's massive Dhaulagiri range, which robs life-giving moisture from Dolpo. During the brief summer, monsoon clouds from the Bay of Bengal are stopped by the peaks of the Dhaulagiri. Only occasional showers fall on Dolpo's thirsty soils. In September the skies clear and the land desiccates. Temperatures plummet. By December Dolpo is a virtual mountain desert, impenetrable behind walls of ice until spring.

Because the land is too poor and too arid to yield more than half a year's supply of grain, the people of Dolpo, known as the Dolpo-pa, depend on trade to supplement their harvests. In a pattern of barter as old as the region's first settlements, they travel north to Tibet in July with their yak caravans to trade barley from their fields and corn from the south for salt from the flats surrounding Lake Drabye.

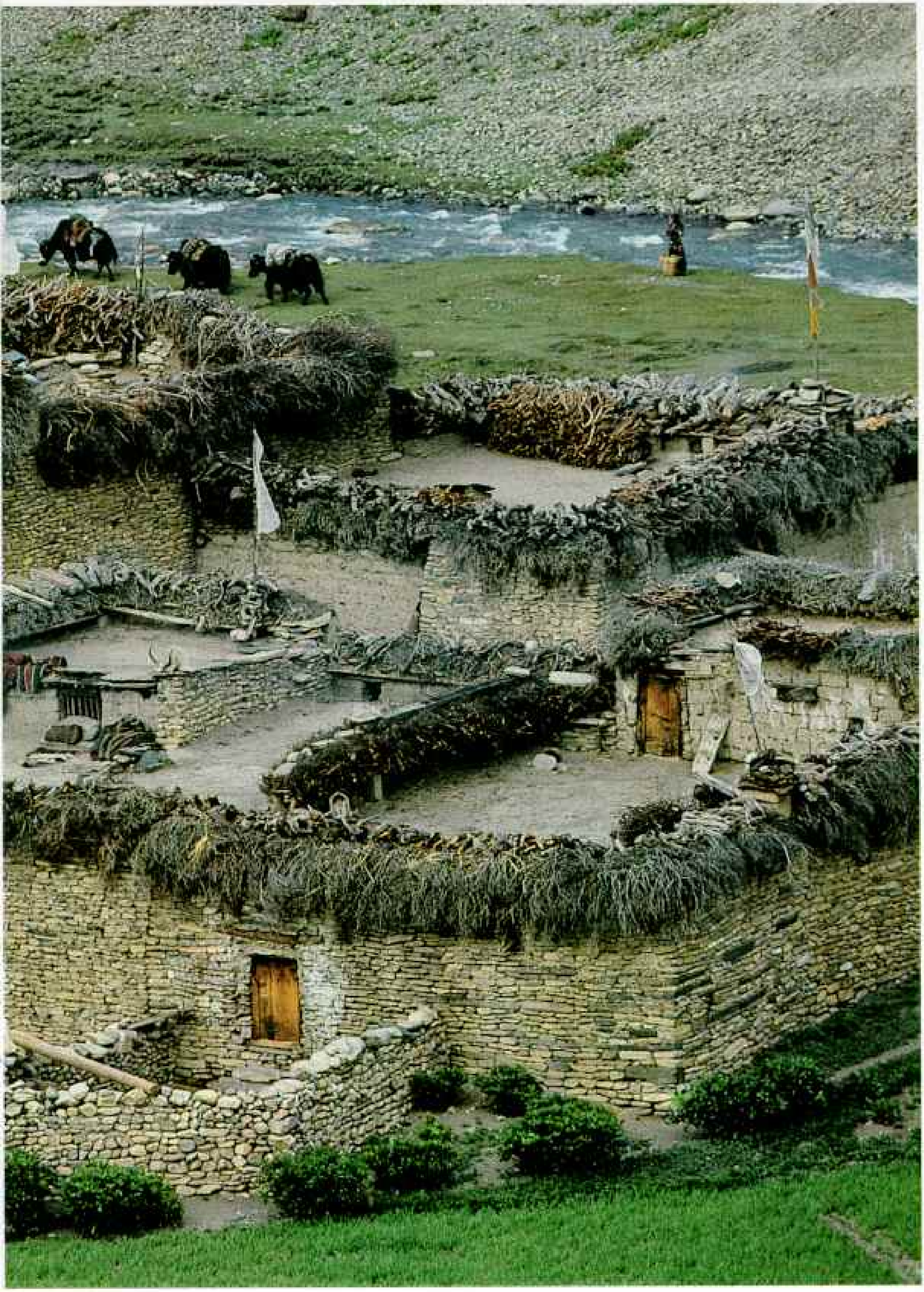
They keep part of the salt for themselves and for their animals. The rest they take south over some of the highest passes in the world to trade for corn and other grains grown on the southern flanks of the mountains. The profit made by the Dolpo-pa on the transactions allows them to survive year-round. It is a trade of life.

During the past 12 years my husband, photographer Eric Valli, and I have made many visits from our home in Nepal's capital, Kathmandu, to the high mountain valleys of the Dolpo-pa. We have walked more than a thousand miles with their caravans. Sometimes our daughters, Sara and Camille, have come with us. We have lived with the caravanners, shared their campfires, listened to their stories, caught the same lice, faced the same icy winds. We have grown to love this land and its people, who until recently have been largely untouched by the outside world.

Laughter comes easy over morning tea for Puti Ongmo and daughter Tsiring Kunsang. Women and children of the Dolpo people, or Dolpo-pa, tend summer pastures while the men are off trading for Tibetan salt. When the men return, most families will begin the long trip south.



Crowned with dried juniper and honeysuckle, the house of a Dolpo trader is a roadside landmark for yak caravans. The dwelling's name in Tibetan, Tsuktso, or "wealthy



house," tells its story; as the owner prospered, he expanded the house to shelter his sons' families. They use the rooftop brush to kindle yak-dung cooking fires.

Settled centuries ago by people from Tibet, Dolpo has remained a pocket of traditional Tibetan culture in this fast-changing part of Asia. When the Chinese clamped down on Tibet in 1959, their occupation stopped at Nepal's northern border. To the south the nearest airport is still ten days away by foot through passes open only eight months of the year.

Yet change is starting to arrive here. For the first time—in a land where fire is still made with flint, yaks take the place of the wheel, and villagers worship the gods of the mountains, sky, and rivers—we have seen cans and plastic bags along newly opened tourist trails and met children wearing Mickey Mouse T-shirts and ragged nylon pants instead of the usual woolen tunics and felt boots. One by one, the caravans between Nepal and Tibet are disappearing.

Before the 20th century pervades this land of the past, we want to document the last great caravans of the Himalaya.

Measure for measure, one bowl of salt fetches two and a half of corn as lifelong trading partners do business in Hurikot, Nepal. Each year traders haggle over prices and winter grazing rights in a barter that has bound the Dolpo-pa and the Rong-pa for centuries.

ACROSS THE MOUNTAINS to the south another ritual is being performed. The participants are not Buddhists like the Dolpo-pa but Hindus. Their culture comes not from Tibet but from India. They do not scratch a living from the highlands but plow the fertile foothills of the Himalaya. They are the valley people, or Rong-pa as the Dolpo-pa call them, and their lives are intertwined with the Dolpo caravanners.

Tonight people in the Rong-pa village of Chuma are gathered in a small wooden temple to consult a shaman. The mud floor has been smeared with a purifying layer of fresh cow dung. Strips of red and white fabric hang from the low ceiling. Roughly carved wooden statues personifying the gods of the village stand on the far side guarded by the trident of Siva, a Hindu divinity. Oil lamps spill yellow pools of light.

The shaman is dressed in white from head to ankles. A long braid of his hair is coiled in a topknot. He sits immobile while his assistant rings a bell to call the gods. Villagers of all ages sit around him. The atmosphere is jovial. Eric asks an old man holding his sleeping grandson on his lap how long before a god comes.

"If we are lucky, the spirit will come quickly. Sometimes it takes longer. Other times it will not come at all," he replies.

A wooden plow hangs on the wall. A chicken is nesting in the corner. Suddenly the old man jabs Eric with his elbow and points to the shaman, who slowly rolls his head from left to right, yawns, and grimaces. He jumps like an animal around the primitive wooden statues. The bell in his hand rings erratically as he shakes. His braid falls to his waist. All eyes are fixed on him.

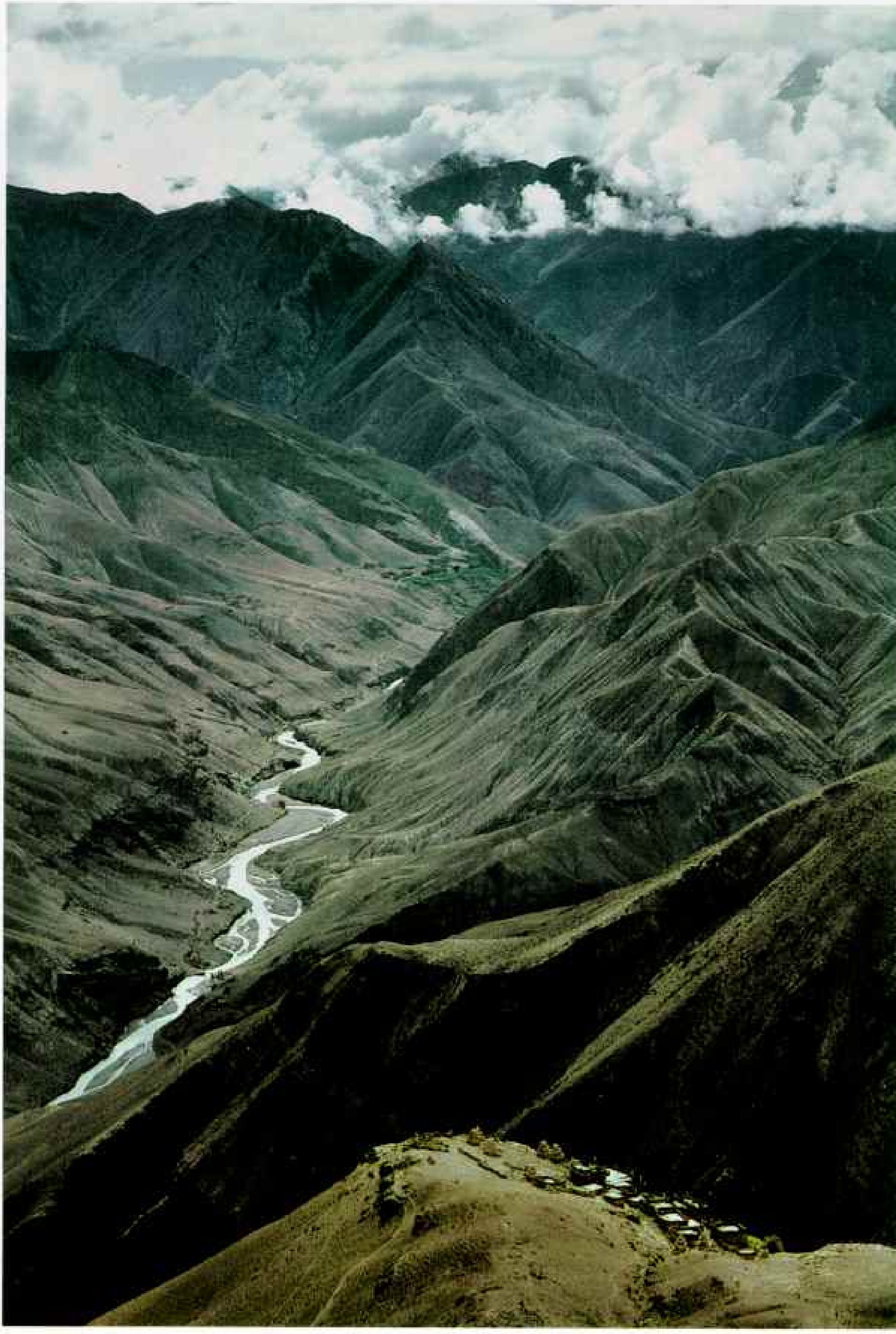
In front of him is a pile of uncooked rice. With his right hand, he flattens it and with the tip of his finger draws some strange signs in the grain. His eyes seem to be looking inward,

An ancient cycle of trade

In the high and dry reaches of northwestern Nepal, the Dolpo-pa can grow only enough grain to feed themselves for half a year. They must trade for the rest, first guiding yak caravans across the Chinese border into Tibet to trade barley and corn for salt—a dietary necessity in short supply in Nepal. Then they turn south, driving salt-laden caravans through mountain passes to reach the foothills of central Nepal, where grain is plentiful.

Awaiting them are the Rong-pa, a people rich in grain, who need salt for themselves and their large flocks of sheep and goats. Chinese restrictions now limit how much Tibetan salt the Dolpo-pa can offer, so after trading with them the Rong-pa load their animals with saddlebags filled with red beans and take caravans farther south to trade for salt from India.

Himalayan Caravans



rather than out at the audience gathered in front of him. The closest man asks him a question. The shaman takes a handful of rice, which he pours into the palm of his other hand. The grain runs between his fingers. The shaman starts to speak in a high-pitched voice, as if possessed by the god.

"No, you cannot leave the day after tomorrow. This is a bad day," he tells a sheep caravanner. The shaman decides the date of departure for every flock.

"But everything is arranged with people from another village," says the caravanner. "We are supposed to go together. An offering and a sacrifice to the gods should fix it."

"It is not that easy. You remember, last year you promised to bring back a temple bell from the south."

"I was sick. I will bring it this time."

The shaman impatiently shrugs his shoulders without listening to the man's answer. He murmurs a prayer, tosses rice into the assembly, and turns to the next person waiting to consult him.

Like the Dolpo-pa to the north, the people of Nepal's middle valleys live by the salt trade. While the Dolpo-pa lack water to grow enough grain, the Rong-pa lack salt to feed their sheep and goats. To them salt is the "breath of life." They prefer Tibetan salt from the Dolpo-pa, but since the supply from Chinese-controlled Tibet is uncertain, they must look for more elsewhere. The Rong-pa too are caravanners, taking red beans to southern Nepal to trade for rice and iodized salt from western India.

It is late at night now. The caravanner returns to the Chuma temple and begs the shaman for help in solving his problem.

"La! Thik cha!" the shaman says. "Fine! Take this handful of rice. Put half of it on the beam above the entrance to your house. Spread the rest on your sheep and goats on the day of your departure. Sacrifice a lamb to the god of the forest at Ranga Chautara, and do not forget to bring the temple bell."

The caravanner smiles as he backs out of the temple. Now he can leave as planned.

Two cultures. Two climates. Two ways of life. Linked together by need, the yak

Using his teeth to tighten the lashings, a Dolpo trader and his wife strap 60-pound bags, fadse, to a yak and set out for Hurikot in central Nepal. Each yak carries two fadse of salt as it plods across serrated ridges (left). Acclimatized to Dolpo's high altitude, yaks do best above 10,000 feet.

Treasures of trade adorn a Dolpo woman, whose silver tik-pu, *a Tibetan headdress, was a wedding gift from her husband. China's takeover of Tibet in the 1950s stopped at the border of Nepal, where the Dolpo-pa survive with their Tibetan culture largely intact.*

caravans of the Dolpo-pa and the sheep caravans of the Rong-pa are the bloodstream of the Himalaya, moving the essentials of life back and forth across the mountains.

IT IS OCTOBER NOW in Dolpo, and the harvest is finished. New leather soles are stitched onto felt boots, and the click-clack of looms is heard in every home as women finish weaving woolen threads into brightly striped blankets. It is time for the yak caravan.

Tilen Lhundrup is caravan chief of the village of Saldang. A hard life has left deep wrinkles on his face and work-worn hands, making him look older than his 51 years. To hide his thinning hair, he wears his plait to one side. "Girls don't like balding men," he jokes with an engaging smile.

By November the temperature is dropping. In the mornings the streams are covered with ice. A piercing cold will paralyze Dolpo for the next six months. Only the lamas can divine the most auspicious date for the caravan's departure from Saldang. Every day the villagers anxiously watch the skies for the first hint of winter storms, wondering if the caravan will get out before snows block the passes to the south. Finally word arrives.

"Tilen. . . ." A voice is carried on the wind. Tilen climbs the ladder to his rooftop and yells back to his neighbor.

"What do you want?"

"The lama knows. We leave in ten days."

The chant of lamas and the trumpeting of conch shells announce that the ceremonies of departure have begun. Handfuls of barley are thrown into the wind as offerings to the gods, who must be appeased to ensure a safe journey and to protect their houses while the caravanners are gone.

"Lha gyalo!—May the gods be victorious!" Tilen cries lustily to the sky. He ties freshly printed prayer flags to corners of the terrace. The long, white flags beat in the wind, releasing prayers to the gods.

The village butcher comes to Tilen's courtyard one morning to kill a yak. Tilen is forbidden by Buddhist precepts from taking another creature's life. Once the deed is done, Tilen

plunges his arm inside the animal's chest and draws out a cup of blood. He drinks slowly.

"How does it taste?" I ask.

"Not good," he replies, but he says it protects him from lowland diseases such as malaria and dysentery.

Life would be impossible here without the yaks. They give yogurt and cheese, butter for tea, hide for shoes, wool for blankets, dung to fuel cooking fires in a treeless land. "Yaks are our parents," says Tilen. "They carry our loads. They take care of us."

Departure day finally arrives. The yaks are loaded with *fadse*, bags woven of yak hair and sheep wool, that are plump with salt. Whistles, shouts, the excited chatter of children, and the tinkling of bells fill the cold morning air. As Tilen's animals pass through Saldang, long bands of clouds cross the sky from the south. The lead yak, red tassels dangling from his ears, a prayer flag stitched into his thick coat, heads the others down the trail to the south and to the corn of the Rong-pa.

Over a period of ten days, 2,000 yaks and hundreds of people will leave northern Dolpo for the land of the grain. They travel in groups of 50 to 150 animals so as not to overcrowd the campsites and pastures along the way. It will take them about three weeks to reach the villages of the Rong-pa. Everyone has heard rumors that the price of salt has fallen again. Every year it seems to get lower, making the caravan a bigger economic risk.

SO MUCH HAS CHANGED, Tilen says as he walks beside his yaks. Even the salt is more difficult to obtain now. For the past few years when he and other Dolpo-pa journeyed to Tibet to trade their grain for salt, they have been forced to follow the rules laid down by Chinese officials.

"They told us we could come only on three days in July," he says. Traders who were late would be penalized. No one wanted to be late, so all the caravanners joined the trail at the same time. "The line of animals leaving Dolpo was this long," he says, gesturing with his hands.

The trading took place at Kyato Chongra, a seasonal marketplace one day north of the Nepalese border. Two hundred white tents dotted the grassy plain. There Tilen and the others met the Drok-pa, nomadic herdsmen of the Chang Tang, part of the Tibetan Plateau.*

The Drok-pa brought salt from the shores of Lake Drabye, ten days away. "They are our people," says Tilen. "We speak the same language, we have the same gods."

"A Drok-pa appointed by the Chinese came to our tent," Tilen tells me. He recorded all the goods to be traded, decided who could trade with whom and how much they could barter. The Chinese government set the rate of exchange. "We used to get 21 measures of salt for 10 measures of grain. Now it's only 17. *Ke garne?*—What to do?"

Besides salt, the Drok-pa also brought dried cheese, sheep, wool, Chinese tea, fabrics, borax, and porcelain cups to trade. For their part the Dolpo caravanners offered barley and corn, potatoes, buckwheat, turnips, and a few foreign goods from Kathmandu.

"A *japan panasanic* was worth four sheep," Tilen explains, referring to a battery-powered cassette player. "A *seeko* watch was worth two or three."

I'm surprised at how easily these foreign brand names slip off the tongue of this rugged caravanner—names that, in these wild mountains, seem to belong to another world.

Our days soon take on a familiar rhythm. At dawn Tilen's son Chewong rises from the circle of sleeping bodies and, without a word, leaves camp to bring the yaks down from the slopes, where they grazed overnight. The yaks are gathered in a group for loading. The men move slowly through the forest of horns, clicking their tongues to calm the beasts. Tilen's daughter Dawa holds a yak's horns as Tilen hoists 60-to-80-pound salt bags onto wooden saddles. Gripping the rope with clenched teeth, he tightens the knots. Blankets, pots, and pans are tied to the loads.

"Ke yo!—Go!" a caravanner shouts, whirling a long slingshot over his head. The stone spins out and hits the rump of the lead yak. The beast quivers. In a chorus of bells and whistles the caravan sets off. Women and children follow. Those too young to walk all day ride mountain ponies. Babies are cradled in blankets on their mothers' backs. A man who injured an ankle rides a hornless yak.

The caravan does not stop until late afternoon. The caravanners unload the yaks, which wander off again to graze.

"Ko, ko!—Come!" sings a caravanner. "Up there, you, *(Continued on page 22)*

*Melvyn Goldstein and Cynthia Beall reported on "The Remote World of Tibet's Nomads" in the June 1989 NATIONAL GEOGRAPHIC.

Demons and divinations

Worry lines the face of Tilen Lhundrup (opposite, below), leader of a yak caravan, as he hovers over Sara, the four-year-old daughter of author Diane Summers and photographer Eric Valli. "Are you cold, little one?" he whispers.

Sara fell ill as the family fought through a snowstorm on the trail in Dolpo. By the time they arrived at Tilen's camp for the night, she was nauseated and running a high fever. Eric and Diane grew more alarmed when they reached the village of Saldang; despite the medicine they had given her, Sara was worse.

Tundup (top right), their host and the village doctor, takes one look at Sara—who by now is delirious—and with a toss of two dice performs a mo, or divination. "Demons are making mischief," Tundup concludes. "They see your daughter dressed in nice clothes and carried by a porter like a rich child. They are attracted to her, but don't worry. It will pass soon. She has a strong life force."

For good measure Tundup suggests that he and Eric travel to Yang-tsher Monastery—about four hours away—to ask the lamas to include Sara in a village exorcism.

At the monastery lamas dressed as fierce gods (left) dance and chant prayers for Sara and others suffering illness. Cymbals clash as a lama presents a paper stamped with images of demons and destroys them by tossing it into a fire.

Later Tundup suggests that Sara take the name of a blacksmith's family and wear miniatures of the craftsman's tools (below left) to trick the demons into believing she is of a lower status. Eric and Diane politely decline. Sara is better—for whatever reason—and they are grateful.

Pausing to catch a breath, eight-year-old Pema Angyal and his horse guide yaks across Kimbu La, first of four passes that usher the caravan into the central valleys. Dolpo

children begin taking on responsibility as early as four years old. Pema's job includes caring for the horse and securing its pack as the caravan lumbers southward.

the spotted yak, don't go so far. We are staying here tonight." He brings the yak back.

The men build a wall with salt bags as a shelter against the wind. The acrid smoke of a yak-dung fire wafts through the air. At the fire Tilen dips a ladle into a pot of bubbling stew. He pours some into a wooden cup, then swirls the contents like a glass of burgundy. His hungry family watches. Tilen lifts the cup to his lips, then moves his head slightly in displeasure. He dips his hand into a woolen pouch and sprinkles salt into the stew.

Finally Tilen scoops out the stew into the waiting dishes. Before commencing, everyone dips their fourth finger elegantly into the stew and flicks the droplets in the four directions. *"Chur!*—Please take!" they say, offering food to the gods first.

Despite the severe cold, the caravanners sleep in the open. There is no shyness or prudery. By the crackling fire, men, women, and children disrobe to sleep naked together under layers of blankets and sheepskins. It is a cloudless night, and the snow of the pass glows under the moonlight like the numbers on a watch.

IN THE MORNING it is minus 2°F. Dawa reaches out of the woolly cocoon to grab a belt on which a flint hangs. Sparks ignite. A wisp of smoke curls. She gently blows on the smoldering tinder, then places it in a pile of dried yak dung. She squeezes bellows of marmot fur. A flame erupts. She puts a pot of ice on the fire. The rest of the family stays under the covers, sipping bowl after bowl of buttered tea until the first rays of sun touch the camp.

The streams and torrents are mute now under a thick carapace of ice. Winter has come. The caravanners, like sailors, depend on the weather. If a blizzard catches them when they are crossing a pass over the mountains, they can all lose their lives.

After nine days on the trail we reach the foot of Baga La, the most difficult of four passes. The caravanners are tense. At the camp Tilen scans the sky. He throws a handful of salt onto the fire. Everyone is silent. If the salt is dry, it crackles, meaning snow is far away. If the salt is wet, it stays silent, and storms are approaching. The salt sputters. Everyone breathes a sigh. The gods are with us. Despite heavy clouds, snow does not fall.

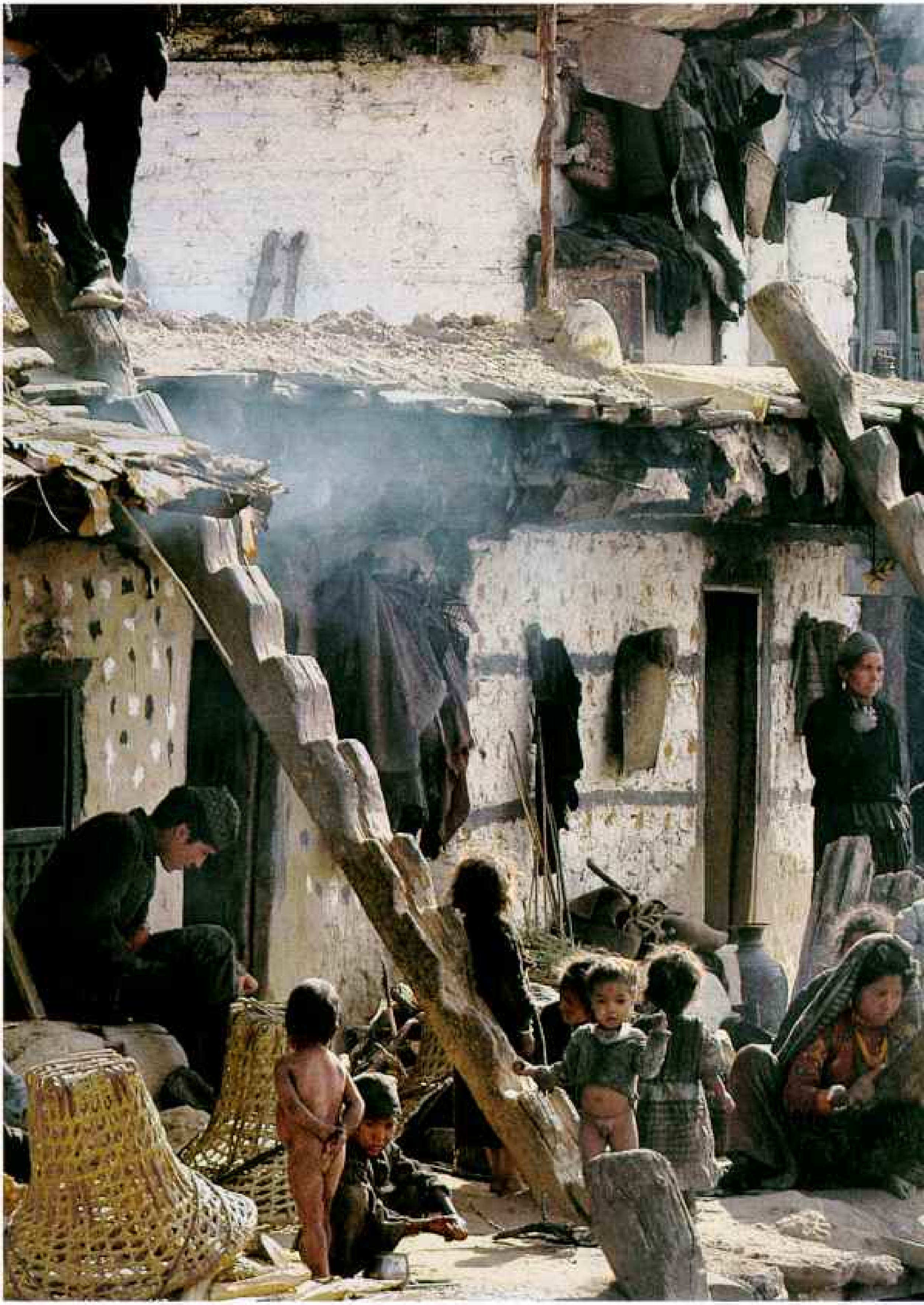
Four hundred yaks—from Saldang and Namdo—climb the slope to Baga La. The broad, zigzag trail is icy and treacherous. Women smear a black substance made from roots beneath their eyes to protect them from snow blindness. The men wrap their long braids over their eyes.

At the summit every man, woman, and child cries homage to the gods and tosses a stone onto a cairn. On this altar to the mountain gods, scores of prayer flags whip in the icy winds. The deep breathing of the animals, the knock of their hoofs on the frozen earth, the creaking of ropes and saddles, the whistle and shouts of the men echo in these towering

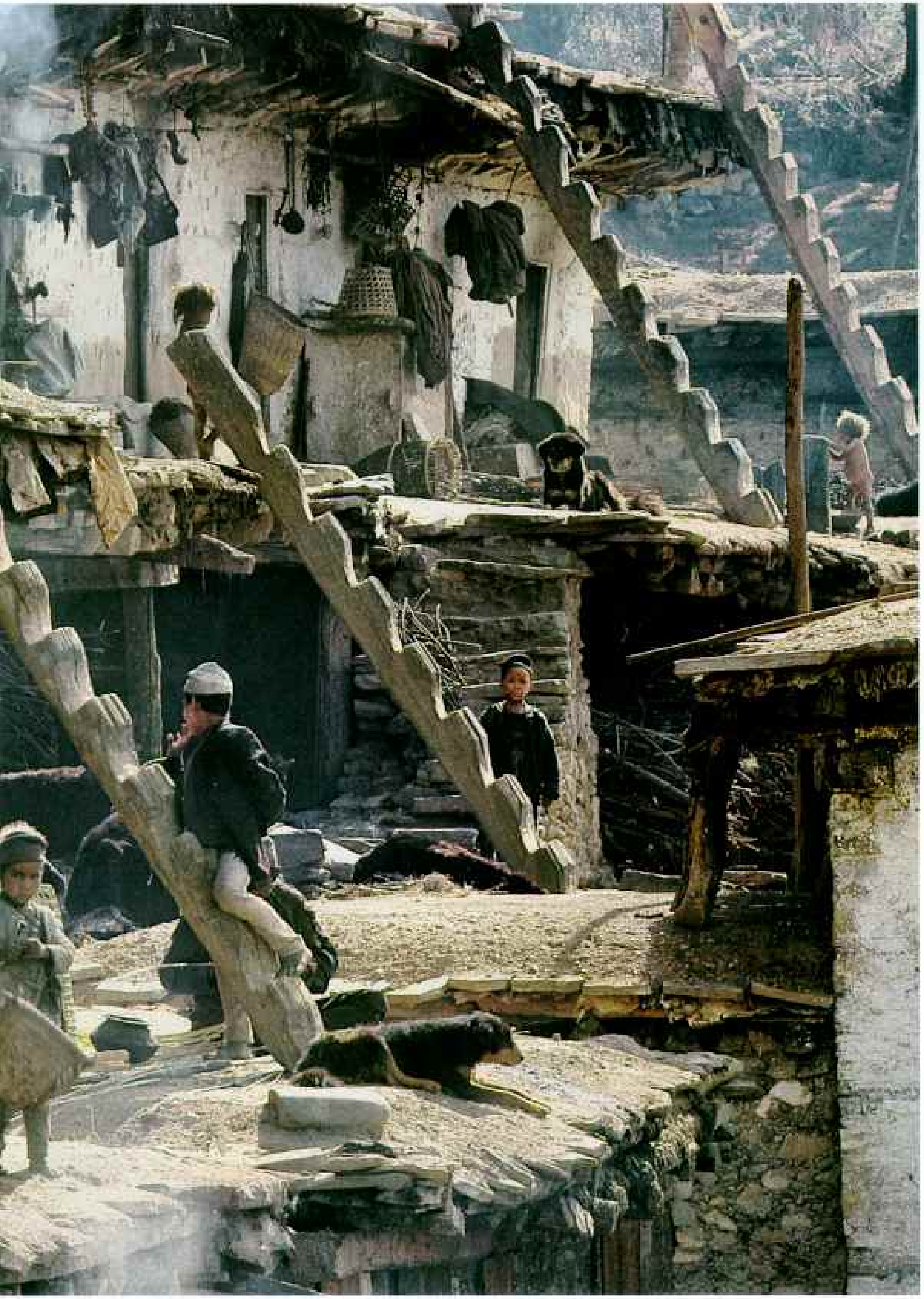
mountains. After the passage of the caravan, there will be silence again for months.

From a height of 16,568 feet on top of the pass the caravan quickly descends to below the tree line, a drop of around 5,000 feet. After spending so many days in the scree and barrenness of the high altitude, it is a delight to smell the loamy earth and the scent of pine needles, hear the birds, and feel a breeze rustling through the birch trees. Spirits are lifted and the mood is light, like a summer day's picnic. It is a gloriously blue day, and the dusty fields of northern Dolpo already seem a world away.

To shield themselves from the wind on a November night when temperatures plunged to 14°F, Dolpo caravanners built an arc of fadse, saddles, and other gear. The next morning, one day from their destination, they melt ice for morning tea—a steaming broth flavored with yak butter and salt. "Tea is the horse of the traveler," says one caravanner. "It gives us energy and keeps us going."



Living in an up-and-down world, villagers clamber from terrace to rooftop on notched ladders in Talphi, where Rong-pa residents await the Dolpo salt caravans. Says



caravan leader Tilen: "Our language, our ways of life, even our gods are different, but that has not stopped us from trading with the Rong-pa."

EIGHT DAYS LATER the caravan reaches the village of Hurikot. Here most of the people are Hindu. Women wear long skirts and short bodices of cotton. Men wear the *topi*, the traditional Nepalese cap, and a black jacket over cotton shirt and trousers.

Tilen greets Budhi Dhami, his *ista*, or traditional trading partner. Their families have done business together for longer than anyone can remember. Beer has been prepared for the family's arrival, and two rooms have been cleaned in the house for their winter stay. Other villagers have come to discuss this year's trading rate for Hurikot. While talking, they discreetly count the number of Tilen's fadse piled on the terrace. Brass bowls are filled with beer. Negotiations begin.

"The Chinese did not give us much salt this year," says Tilen. "I could only bring 12 loads [about 1,500 pounds]." For his part, Budhi complains of the lack of rain, the bad harvest, and the neighbors' cows, who ate half the crop. On top of that Budhi's wife has been sick. All the bad news is brought out to set the mood.

Finally Tilen asks for four measures of corn for one of salt. As leader he is responsible for negotiating the trade for all of the Dolpo-pa, including their right to pasture their yaks in the surrounding valley. The Rong-pa offer only two measures of corn for one of salt. Last year it was three to one. The year before four to one. The discussion hardens.

Tilen will not trade below four. The Rong-pa answer, "No trade, no pasture, and we will levy a tax of five rupees [12 cents] per man or beast for crossing our land."

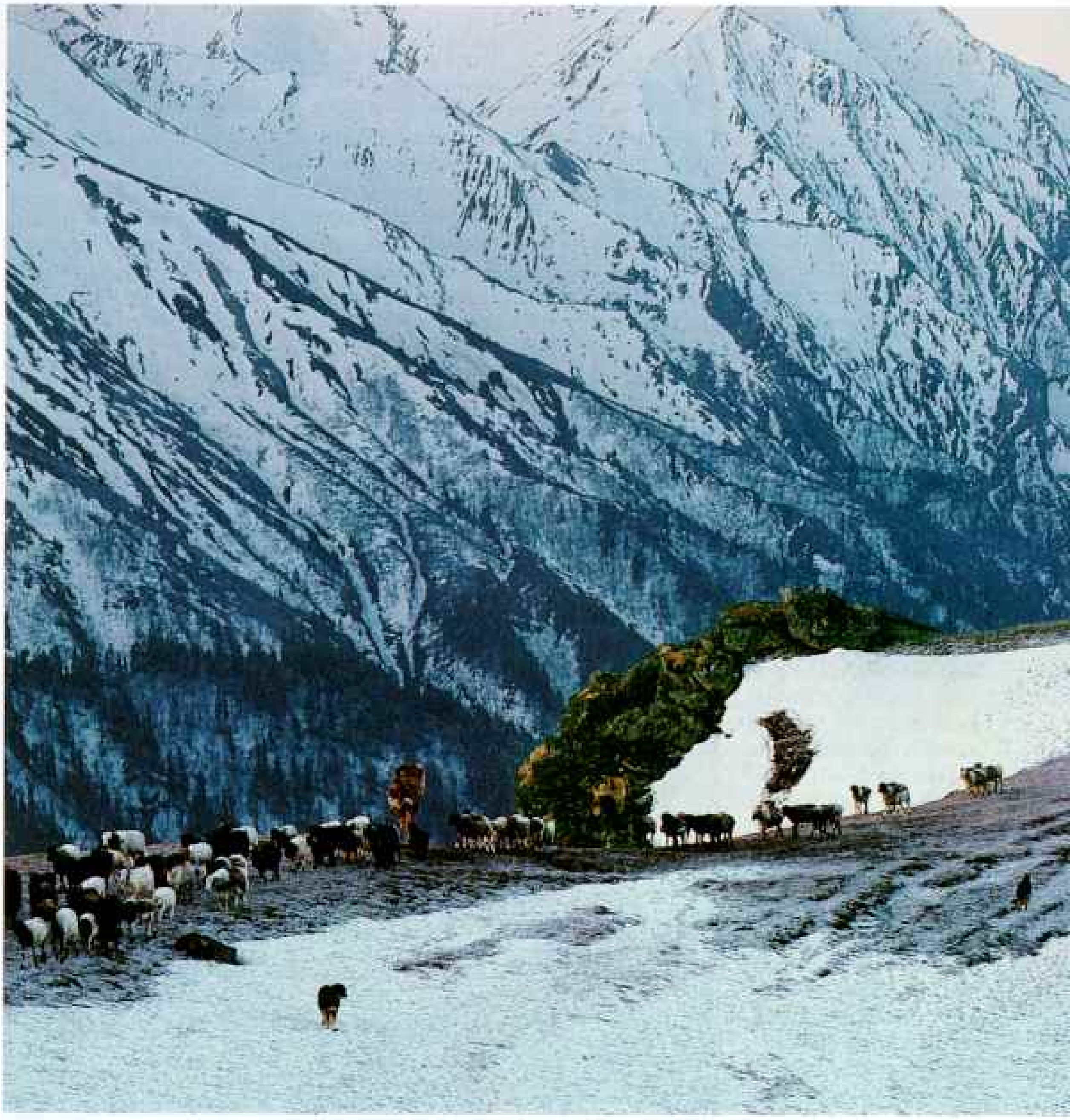
By the end of the evening the only thing the Rong-pa and Dolpo-pa agree on is that they have three days to decide the rate. Rumors fly. Some say that in a nearby valley the official rate was one salt for two corn. Others say it was three. Finally the rate is fixed: one measure of salt for two and a half measures of corn. The Dolpo-pa are bitter. Never have they been offered such a low rate. But at least the pasture rights are secured.

The next day as we reach the foot of the mountains, we meet another loaded caravan coming from a side trail. Eric recognizes the sons of Tilen among the men. Discreetly, he presses his fingers against the thick woolen bags and feels the rough salt crystals.

"We had to hide some salt in the mountains," Tilen says with a smile. "You show too much and the rate drops! The rate in Hurikot is so low that it barely allows us to survive. We have to go farther and trade the rest in the Chaudhabise Valley. People say the valley is starving for salt."

Tilen is clever. He leaves enough salt with his ista so his winter pasture rights are assured, then he takes the loads that were hidden in the mountains on the five-day walk to the valley.

As negotiations end, Nanda Lal, chief of the Rong-pa village of Chuma, pours Tibetan salt into a measuring pot. He and Tilen (left, at left) fix this year's local rate of exchange—one measure of salt for four of corn. The Dolpo-pa winter in the valley; the Rong-pa feed their sheep salt (above) and move south to trade for more.



"WHAT A PROSPEROUS PLACE," Tilen says of the Chaudhabise Valley, looking at the thick forest, the streams, and the fields. Nanda Lal Thapa, a well-known trader, lives here in the white cluster of houses that is the village of Chuma. He is a Hindu, born into the Chetri, one of the highest of the castes that layer Hindu society. His fine features and slight build are typical of the valley people. He wears a thick cotton turban and smokes a chillum.

Like Tilen, Nanda Lal is a leader. He has to defend the interests of his people. When Tilen asks for five measures of corn for each measure of salt, Nanda Lal smiles and offers three. Tilen, holding a cup of buttered tea, slowly speaks.

"We brought the salt all the way to your doorstep, and you offer hardly more than Hurikot? You have been to Dolpo before. You know the pains we took to reach your beautiful valley where you have everything: water, wood, rich soil, corn, wheat, buckwheat, apple and apricot trees, even some rice and meat of wild boar and goats. But what does the best food taste like without salt? Salt, and you know it, is much more precious than the gold you put on your

Icy ramparts signal danger at Chakhure Lagna, at 13,589 feet the highest pass traversed by southbound Rong-pa sheep caravans on the trail to Bhotechaur, a trading center in southwestern Nepal. Jackals and leopards lurking in nearby forests often attack the sheep, picking off stragglers and lambs. To protect them, men keep watch during the night while mastiffs are posted around the camps.

women. How can you offer only this much?"
At the door the Rong-pa stand silently around Nanda Lal. They are taken by Tilen's words. What he said is right. Nobody can deny it. The rate is fixed at four measures of corn for one of salt. Then Tilen says cleverly, "As we had to walk all the way to your village, the farthest in the valley, you have to give us food and firewood during our stay."

Nanda Lal proposes a *mana* (pint) of corn for each sack of salt. "What?" exclaims Tilen in surprise, "a mana is just a handful. The mice will eat that much from my bags." Tilen wins five more mana for each sack of salt.

When the bargaining is done, Tilen congratulates himself. The rate in the Chaudhabise Valley is almost double that of Hurikot. Tilen has business in his blood.

THE TRADING IS FINISHED NOW for the Dolpo-pa, most of whom will spend the winter near Hurikot. For the Rong-pa, however, a new cycle of trade is just beginning. The salt from Tibet is not enough. They must take their sheep and goats south to trade for Indian salt.

Nanda Lal, the leader of Chuma's caravan, calls his flock of 150 sheep and goats the *pahar ko gadi*, or truck of the hills. Many animals are loaded down with a double-pouched saddlebag filled with red beans. When he smiles, Nanda Lal's face breaks into wrinkles, and his voice is gentle with the strong accent of his people. Though he says he is 61, he looks more like a boy as he chases his errant children or jumps across a stream. Except for a grimy white turban, every piece of his clothing is spun and woven from his sheep: a coat with a long curved needle in the lapel, a waistcoat, and baggy pants.

We sense the differences right away between the worlds of the yak and sheep caravanners. While Tilen is a rugged mountain man, Nanda Lal is a gentle shepherd. While Tilen will chew strips of dried yak meat, Nanda Lal eats chapatis with spicy potatoes and lentils—his religion forbids him to taste yak meat. Tilen's roots are Tibetan, but Nanda Lal's ancestors come from India. Yaks are big, tough animals that don't need much tending; sheep must be kept close to camp to protect them from jackals and leopards. The yak caravan is a race against the weather to get through mountain passes; the sheep move more slowly, sometimes stopping for a week or even a month where grazing is good.

On the morning of the caravan's departure, Nanda Lal's wife, Jarpa Kali, gives him thick

Bent under the weight of her worldly goods, a young Rong-pa shepherd carries provisions for her six-month journey; a goatskin mattress and an ax for chopping wood ensure that her nights will be warm. To protect against frostbite during the winter quest for Indian salt, the Rong-pa wrap their shoes in woolen rags (below). Feeling their way up worn steps, sheep and goats follow the leader along a cliff's edge (right). On the narrow trail caravanners must constantly adjust the saddlebags; the weight of shifting cargo can throw the animals off balance and send them tumbling over the side.

buckwheat pancakes for the road. She dabs a little turmeric-stained rice between his eyebrows as a blessing for an auspicious journey. She has already mixed cow dung and sacred rice into balls and stuck seven of them on top of the doorway to protect the household from evil while he is away.

Nanda Lal and the other herders will be gone for six months. Their journey will take them 90 miles through fertile valleys of terraced fields tilled by oxen, tall stands of corn, and, lower down, broad fields of rice. Moving ever closer to the roadhead, where they will trade their beans for Indian salt, they will pass through a mosaic of different groups—Magar, Thakuri, Chetri, Brahman.

Nanda Lal's daughter-in-law Rupa Kali leads the caravan out of the Chaudhabise Valley. Carrying her little daughter in a basket, she walks slowly in front of the village's herd of 500 sheep and goats, calling, "Whaa! Whaa! Whaa!" The animals follow in a chorus of bleating.

The shepherds are spread out at intervals of 20 to 30 sheep. Every man wears a belt from which hangs a sickle in a wooden holder and carries a woven bamboo basket on his back supported by a wide strap across his forehead. The basket contains cooking pots, a woolen blanket, a goatskin for a mattress, a cotton tarp to make a tent, a wooden bottle of cooking oil, some red chilies and salt, and a large mass of raw wool that he spins as he walks if the trail is easy. The smell of sweat, smoke, and greasy wool impregnates everything—caravanners, bags, blankets.

Flocks of sheep and goats from different villages often mix on the trail. I am amazed at how easily the herders sort out their own animals, since none has marks of ownership.

"I recognize my sheep as you would recognize your children," says Nanda Lal.

"I do not have 150 children," I reply.

"Yes, but you recognize people of your village by the way they eat, walk, or talk. So it is with my sheep."

THE HARDSHIPS OF THE CARAVAN take getting used to. Because the trail is traveled by tens of thousands of sheep and goats every year, our camps are carpeted by thick layers of manure. The streams are also polluted by so much animal traffic, and though we boil our drinking water and are careful about what we eat, we still occasionally suffer from diarrhea and worms.

What's more, every evening at dusk a thick cloud of tiny, biting flies called *bhusuna* descends on the sheep, penetrating their fleeces. Irritated by the biting, the sheep panic and run. We too are attacked, and our tent offers little protection—the tiny flies go right through our mosquito net. Preferring smoke to the bites, the shepherds huddle around a fire.

As evening approaches, Nanda Lal goes to meet the young shepherds bringing the sheep and goats back from grazing. Never idle for even a moment, Nanda Lal spins while walking among his flock. The distaff drops and twirls like a spider at the end of its thread.

Eric takes his coat and walks out to join him. Nanda Lal is lighting a fire at the foot of two big pine trees. His sheep are huddled under the trees for protection.

"Will you stay here all night?" Eric asks.

"I have to," he says. "There are jackals. I have to take care of my animals."

He sits by the fire on a bed of moss and pine needles. The fire grows, consuming a dead tree trunk. As he mends his shirt with yet another patch, he sings in a high-pitched voice, eyes lost in the sadness of his shepherd's song.

"Ever since I was knee-high, I have tended sheep and goats," he says suddenly. "But my sons are not interested in the animals. When I die, what will happen to my flock?"

Eric cannot answer. The fire crackles in the silence of the night.

FOR GENERATIONS Nanda Lal and his family have stayed with the headman of Diga, a village 40 miles south of Chuma. Mud houses painted ocher and white are scattered among terraced fields green with unripened wheat. Chickens scratch in the courtyards. Water buffalo chew their cud in straw-roofed stables. Nanda Lal and the headman are *mit*, or ritual friends, which means that whenever Nanda Lal is in Diga, he may call freely on the headman for help and ask to pasture his flock on the ridge above the village.

Nanda Lal has brought gifts for his mit—red beans knotted in the cloth of a turban, a wool belt, and a grain called *chino* fried in honey for the children. He stands shyly in front of the headman and calls him raja, or chief.

"Please let us stay here," Nanda Lal says. "You should be able to eat my honey, and I

should be able to eat yours. Give me grass and firewood. My sheep will give you manure, and I will give you salt when I return."

The headman accepts the gifts, but his welcome is strangely cold. He does not even offer a cup of *raksi*, or grain alcohol, as friends normally do. Shocked, Nanda Lal goes back to the camp outside the village. What has happened to the bond between them?

Later the headman, feeling guilty, comes out to the caravan's camp to explain. Sitting at the fire, he says he was pressured by the other villagers into not showing his friendship. "Don't let them eat our grass or burn our wood," they had told him. "We won't have enough for ourselves."

He tells Nanda Lal that he likes him, but that these are tough times. A caravan burns as much firewood in a day as a villager burns in a week. The caravanners pay two rupees per sheep for pasture rights, but the people would rather keep the pastures than the little money they earn. Soon there will not be enough grass for both the villagers and the caravanners. Nanda Lal and his flock move on.

It has been a month and a half since we began walking, and now, with the Himalaya far behind us, the trail has widened and rushing torrents have become languorous rivers. We are only 40 miles from the border with India, and people are cutting trees and digging into the hills. It takes me a while to realize that they are roadworkers. Every day roads cut deeper and deeper into the mountains. Wheels will soon replace the hoofs that since the dawn of time have paced the Himalaya.

The trail gets busier as we approach Bhotechaur, the bazaar at the roadhead. Porters pass us carrying dried ginger and butter from mountain villages, their bare feet spread over rocks, their calf muscles flexing. Men go back and forth, exchanging information about the best places to trade, the best rate, the best shops. Nanda Lal puts on a sweater knitted by his wife in the hope that someone will offer to buy it.

Bhotechaur has the feel of a frontier town. Shopkeepers have erected a few straw-and-mud shacks to do business with mountain people who trek down from their villages. As

Tucked in and tied down, a baby is the last item packed in a cargo basket as sheep caravanners approach trail's end. The harsh life takes a heavy toll on Rong-pa children: Of those under five years of age, about 30 percent die each year from diarrhea, pneumonia, measles, and other diseases.

The journey home is solemn for a Rong-pa caravanner. His people have enough salt to last another year, but change is coming: Farmers along the route have less land to support his sheep; his friends, the Dolpo-pa, return home to more and more tourists who introduce new ways; Tibetan salt is harder to come by as Chinese officials impede trade. For now the caravanners will continue their travels—but they know the next trek could be their last.

the roadhead moves, so will the shops. Nanda Lal strolls along the wide dusty path, looking at the stalls filled with bangles, saris, shoes, plastic buckets, aluminum pots and pans. He gazes longingly at watches and transistor radios that he could afford only after two years of hard saving. No matter that he can't read the time. It is enough to wear a watch as a status symbol or to sling a transistor radio over his shoulder like a government official.

His hands fumble in the folds of his waistband to draw out a few crumpled rupee notes wrapped carefully in plastic. He sold two sheep at a village on the way. He buys a brightly patterned piece of cotton for his wife and a few sweets wrapped in pretty paper for his grandchildren. At one shop he points to a copper pot. The shopkeeper, after agreeing to the price per kilo of the metal, weighs the pot on a scale. He taps numbers on a black box that Nanda Lal has never seen before. At the end of his calculations, the shopkeeper announces the price: 500 rupees (about $12). Too shy to say he does not have enough money, Nanda Lal slips silently away without the pot.

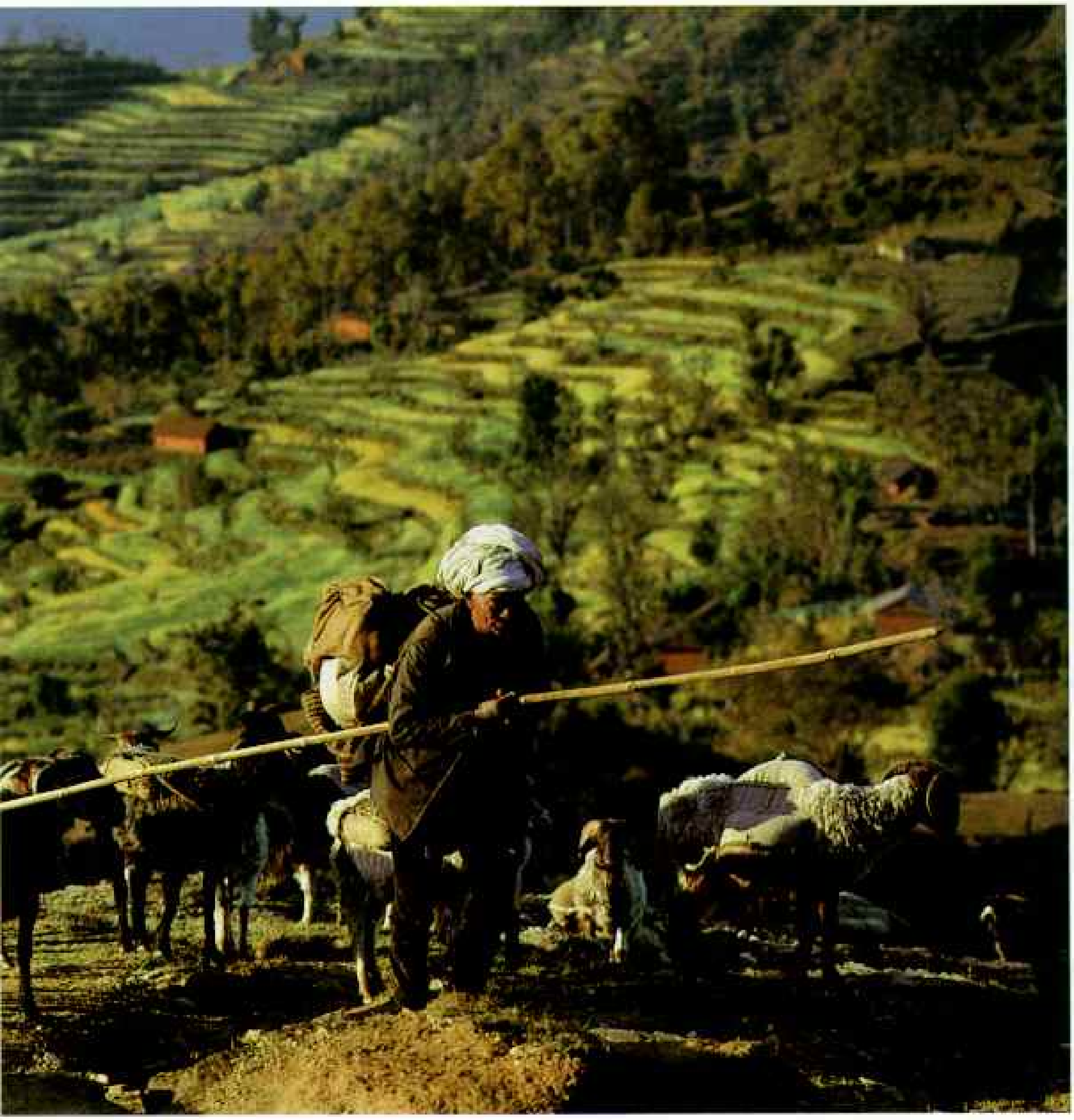
Tonight Nanda Lal sleeps in the back of a shop. The storekeeper, whom he knows well, gives him food. Then in the morning they trade. The shopkeeper allows him the privilege of measuring both the beans and the Indian salt. It is a token of his trust in the old caravanner. The rate is one measure of beans for three measures of salt, a good price. The shopkeeper also gives Nanda Lal an extra hundred rupees to "eat fish on the way back home," a luxury. He wants Nanda Lal to come back next year to his shop.

His trading done, Nanda Lal begins the slow journey home. He leaves Bhotechaur at the right time. Just after he made his deal with the shopkeeper, word spread that a truck had broken down, blocking the road. The shopkeepers now are using the temporary shortage of salt in the bazaar as an excuse to raise their prices.

"The gods were with me," Nanda Lal says.

As I write these words at my home in Kathmandu, I remember our friends in Saldang and Chuma with admiration. Though their days on the trail are harsh, I know they prefer the life of the caravans to staying in the village. Their animals give them freedom to trade and freedom to roam the mountains. In their hearts they are nomads.

Within a few years, however, all might



change. As roads push into the Himalayan foothills, trucks carrying Indian salt may replace the Tibetan salt trade completely. If that happens, the traditional barter that has allowed Dolpo to survive will collapse. The caravans will be finished.

The Nepalese government recently opened Dolpo to tourism as an economic alternative to the old ways. But so far treks are organized mainly in Kathmandu, and because they are largely self-sufficient, they give little to Dolpo's economy. And tourism, I fear, promises to exact a high price from the region's traditional culture. Last year, for the first time, we saw children begging from trekkers.

I would like to think that both the Dolpo-pa and the Rong-pa will find a fulfilling way to the future. I would like to believe that caravanners such as Tilen and Nanda Lal, being shrewd traders, may even profit from the changes that lie ahead. But I have my doubts.

As I said good-bye to Tilen last year and held his hand, I couldn't find the words to make him understand my concerns. He was too busy being practical.

"When you come back, bring something to sell," he said mischievously. "Why take so much pain if it's not for business?" □

By WILLIAM S. ELLIS
ASSISTANT EDITOR

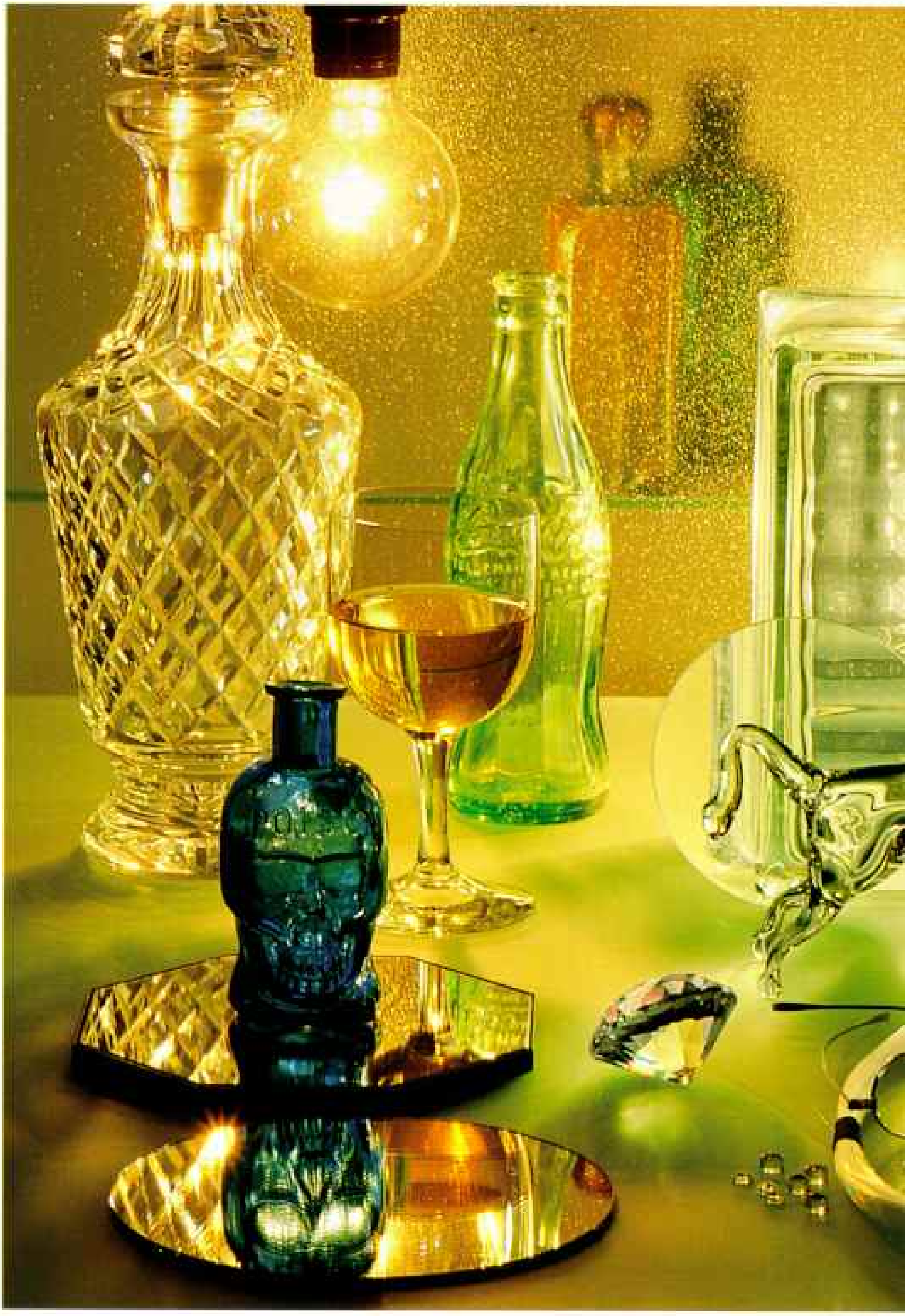
Photographs by JAMES L. AMOS

GLASS

Capturing the Dance of Light

It helps light the darkness, screen the elements, sharpen the acuity of vision, magnify the infinitesimal, and plumb the heavens. It transmits electronic signals across continents and may someday spawn a superbreed of ultrafast computers. Protean glass can also soar with a sculptor's imagination, as in Dominick Labino's nine-inch-high rhapsody in rosy hues titled "Emergence Four-Stage."

PHOTOGRAPHED AT THE CORNING MUSEUM OF GLASS, CORNING, NEW YORK



Mix sand, soda, and lime; cook and cool. Result: a solid with properties of a liquid, a substance that can be blown, molded, spun, and drawn into limitless shapes, textures, and colors. Revered since antiquity for its beauty, glass finds even greater value in the utility of its many modern transmutations.

Glittering cathedrals of commerce house the Gothic-inspired headquarters of PPG Industries, which manufactured these energy-efficient facades. The six-building complex in Pittsburgh is sheathed in nearly a million square feet of double-paned glass with silvery coatings to reflect sunlight.

"You can never force the glass," says Jan-Erik Ritzman, preparing to blow a bowl in his studio near Kosta in southern Sweden. Master glassblowers like Ritzman are often retained by artists to execute their designs. Trained at the Kosta glassworks, Ritzman has worked on his own since 1982. There are no safety nets: "With hot glass, you have to work it until you finish," he says. "You can't stop. You can't go back."

DAWN CAME FROZEN and hushed to the late winter's day, but it was a good warmth that filled the hall at the great Swedish glassworks, Orrefors. It was here I had come to make my vase.

Having observed some of the greatest blowers of glass in the world at work, I was driven by an urge to create my own signature piece—nothing grand, but a modest vase with, I hoped, a certain lyrical quality.

It started well enough, with words from an old Hindi saying dancing in my mind: "If you are a blower of glass, fashion the cup as if it were to be touched by the lips of your beloved."

One end of the five-foot-long pipe for blowing was thrust into a furnace through an opening called a glory hole and twirled around to collect a gob of molten glass, much as a fork is twirled to gather spaghetti. At a temperature of 2100°F the mixture, a variation of the ages-old basic recipe for making glass—silica, sodium carbonate, and calcium oxide, or, simply, sand, soda, and lime—was rude with glaring color, and thick and inching.

Earlier I had watched Juhani Karppinen, an employee at Orrefors for more than 20 years and now a gaffer, or master glassblower, at work and marveled at the way he coaxed form from the molten glass. "You will know by the feel of it on the pipe if it is right," he told me.

Astonishingly, a vase began to take crude shape as I blew into the pipe. I stood atop a box holding the pipe so that it pointed straight down, allowing the blown liquid to swell at the base and pull down to form the start of a neck.

There was more blowing until the glass drew thin and the neck long enough to take the stem of a dahlia. The men assisting me pronounced it done and smiled to signal that it was a vase of some distinction.

It was only after retrieving the piece the next day from the annealing oven, where it was placed to cool over a period of four hours, that I discovered the flaw: When put down, the vase tended to roll from side to side, like a bottle set adrift in the surf.

Glass has been blown that way since the Romans started doing it around 50 B.C. It was long before that, however, when the first man-made glass appeared. The Roman historian Pliny the Elder attributed the discovery to a group of Phoenician sailors who were on a beach preparing to cook over a fire. Finding no stones on which to place their pots, they took from their cargo lumps of natron—an alkali used then in embalming the dead—and rested the pots on them.

When the natron was heated and mingled with the sand, a strange liquid flowed in streams. Wrote Pliny: "and this . . . was the origin of glass."

A nice story, but hardly true. The most reliable research places the invention of glass sometime in the third millennium before the

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JAMES L. AMOS's photographs have illustrated 22 GEOGRAPHIC articles. Among the most recent were "Secrets of Animal Navigation" (June 1991) and "The Life and Times of William Henry Jackson" (February 1989). When not on assignment, he lives in Maryland with his wife, two cats, and a dog.

birth of Christ, in Mesopotamia, or present-day Iraq and Syria.

That is not to say that it is difficult to make glass on a beach, using only materials found there. L. David Pye, director of the Center for Glass Research at Alfred University, in Alfred, New York, set out to do that one day last summer, intent on following a recipe based on an ancient cuneiform text from Mesopotamia: "Take 60 parts sand, 180 parts ashes from sea plants, 5 parts chalk, heat them all together, and you will get glass."

Dr. Pye, of course, had no trouble finding sand along the Chesapeake Bay, in the Virginia Tidewater town of Cape Charles. There was seaweed for soda ash, and shells, when crushed, would provide the chalk. The mixture was cooked over a fire of driftwood at about 1600°F for two hours. The result: not glass.

"Perhaps the fire was not hot enough," Pye said. He turned next to the formula of natron and sand, from the sailors' tale. When that cooking was done, there was glass on the beach. The small piece he retrieved from the fire had a blue tinge to it and was roughly textured. It was not fit for even a bauble, but it was glass.

Pye was delighted. "Even if it didn't happen exactly as Pliny described it, this shows it was possible!"

Sometimes it takes nothing more than a strike of lightning on a sand beach to create glass; it appears in the form of thin tubes called fulgurites. There are also tektites: small, rounded bodies of glass formed as a result of fiery meteorites crashing to earth. Among natural glasses, the most prevalent is obsidian. Shiny and dark, it is born in the fires of volcanoes and was first used by humans to make tools more than a million years ago.

Glass, then, in one form or another, has been long in noble service to humans. As one of the most widely used of manufactured materials, and certainly the most versatile, it can be as imposing as a telescope mirror the width of a tennis court or as small and simple as a marble zinging across dirt. It has given us tumblers for drink and bulbs for light. Glass clears the haziness of failing eyesight, and, as a mirror, it becomes a scepter for vanity (and lets us look at the hidden corners of ourselves).

And, of course, it is glass that allows visual union of the outside and the in—the glass skins of towers and the windows through which are reflected the shadows of our secluded lives.

THE USES of this adaptable material have been broadened dramatically by new technologies: Glass fiber optics—more than eight million miles—carrying telephone and television signals across the nation; glass ceramics serving as the nose cones of missiles and as crowns for teeth; tiny glass beads taking radiation doses inside the body to specific organs; even a new type of glass fashioned of nuclear waste in order to dispose of that unwanted material.

"Glass has so many unique properties—its ease in shaping, its transparency, durability, and low cost—that I think it will be indispensable in the growing communications, information, and electronics industries," said William R. Prindle, a former vice president of the Technology Group at Corning Incorporated, in Corning, New York.

"For one thing, those industries require display systems for their computers and televisions, and glass—either as a picture tube or

Once bright blue, the glass head of an Egyptian king bears the scars of its 3,400 years. Archaeologists believe the piece portrays Pharaoh Amenhotep II, who ruled about 1400 B.C. Less than two inches high, it was probably part of a statuette cast in a mold. Its creator, "without any doubt, was one of the finest artists of his day," says David Whitehouse, director of the Corning Museum of Glass, in Corning, New York.

The earliest known glassmakers worked in Mesopotamia as far back as 2500 B.C., crafting beads and other small objects to imitate precious stones.

A thousand years later, artisans learned to make containers—either by shaping hot glass around a clay-and-dung core or by casting it in a mold. Used to hold ointments, the pieces had limited circulation in ancient Egypt, where only a privileged few had access to glass.

as a thin and flat sheet for a liquid crystal display—is the material of choice."

On the horizon, Dr. Prindle suggests, may be optical computers. These could store programs and process information by means of light—pulses from tiny lasers—rather than electrons. And the pulses would travel over glass fibers, not copper wire. These machines could function hundreds of times faster than today's electronic computers and hold vastly more information.

Today fiber optics are used to obtain a clearer image of smaller and smaller objects than ever before—even bacterial viruses. A new generation of optical instruments is emerging that can provide detailed imaging of the inner workings of cells. Called near-field scanning optical microscopes, they can harness what one scientist calls "the power of photons" to resolve images down to approximately one two-millionths of an inch.

It is the surge in fiber-optic use and in liquid crystal displays that has set the U. S. glass industry—a 16-billion-dollar business employing some 150,000 workers—to building new plants to meet demand. But it is not only in technology and commerce that glass has widened its horizons.

The use of glass as art, a tradition going back at least to Roman times, is also surging. In Seattle and in the mountains of western North Carolina and the countrified south of New Jersey—nearly everywhere, it seems—men and women are blowing glass and creating works of art. In recent years the movement has gained new status, taking leave of the world of craft and ascending into the galleries and slick catalogs and price-upon-request cachet.

PHOTOGRAPHED AT THE CORNING MUSEUM OF GLASS

"I didn't sell a piece of glass until 1975." Dale Chihuly was saying that, and smiling as he did, for in the 18 years since the end of the dry spell, he has become one of the most financially successful artists of the 20th century. He went on to tell me about a new commission—a glass sculpture for the headquarters building of a pizza company—for which his fee is half a million dollars.

More than anyone, Chihuly is responsible for the attention being given to the studio art-glass movement. He has had a one-man show at the Louvre, a rare achievement for an American artist, and just last year had the first show by a single artist in the new Seattle Art Museum. "They chose me rather than a painter or sculptor, so it shows there has been a crossover for glass from the crafts to the fine arts," he said.

Chihuly, a meatcutter's son from Tacoma, has a studio on a waterfront in Seattle, where he and assistants carry his designs to creation. There is no mistaking a Chihuly piece. It is usually

oversize and swirling in opulence, but a work to win the heart.

The studio art-glass movement began in the 1960s under the guidance of Harvey Littleton, who now has a studio in North Carolina and is a legend among artists for whom fire is a palette. Chihuly was his student at one time. Later Chihuly and art patrons John and Anne Gould Hauberg established a place called Pilchuck, where other students could go to learn to work with glass.

Pilchuck Glass School lies 50 miles north of Seattle, in the foothills of the Cascade Mountains. The view from there carries to the waters of Puget Sound. It is here that some of the greatest makers of glass art come each summer to teach. They are masters, and none more so than Lino Tagliapietra, a Venetian, of whom it is said at Pilchuck that as a glassblower, he is without equal.

"Oh, that's not true," Tagliapietra said. "If there is a difference between me and another, it may be because of the facilities and equipment I have. Also, I work with the same people, and the studio has become like a kitchen with everybody making their incredible stuff—incredible food, incredible glass."

Also at Pilchuck many summers is Jan Mares, a Czech, an engraver of glass. He does not blow glass; rather, all of his work is cold. He spends hours at the diamond and copper wheels, cutting and polishing and enfolding bold images in layers of crystal, and hoping, always hoping. . . .

"It is your piece, and you are almost finished with it," Mares said. "Then you do a little final polishing and, you know, make the mistake. You have been with the piece for a month, two months, and then in only a second, at the very last, it can break."

When he is not at Pilchuck, Tagliapietra lives and works on the island of Murano, near Venice. He represents one of the most important traditions in glassmaking.

Space shuttle *Columbia* gets fresh protective skin on its belly at Kennedy Space Center following its 13th mission. Dark-colored tiles made of glass ceramic replace others damaged by debris, especially ice sloughed off the main fuel tank during launch. Composed of 7 percent solids and 93 percent air, the tiles are superb insulators. Seconds after emerging from an oven, a cube of the ceramic can be safely held by its corners while the interior glows at 2200°F.

By the middle of the 13th century Venice was on course to become the foremost producer of glass in the world. Near the end of that century the factories were relocated to nearby Murano, as there was concern of the danger to Venice from all the fires in the furnaces. It is also true that it was easier to contain the craftsmen on the smaller island and prevent them from revealing the secrets of their work to the outside world. Such information was passed along from father to son, and, indeed, it wasn't until the early 17th century that the first book of instructions for making glass was printed in Europe.

The work of the masters on Murano astonished the world. For the most part the glass pieces were blown thin and were light and richly colored—perfect for use at a papal Mass or to hold the unguents of a contessa.

Today in Murano, the tradition continues, although not with the importance of the past. A hundred factories produce glass on the island, but much is low quality, designed for tourists. However, there are still artists of renown there. One is Alfredo Barbini.

Barbini is a man who has spent three-score years and more creating remarkable works of glass art as did his ancestors starting as far back as 1658. "I decided that I would rather work with glass than go to school, so I started when I was 13," he told me. "Two years later, when I was 15, I was regarded as a master."

Barbini is 81, and still by the furnaces on most days, a short, wiry, hard-muscled man, surrounded by the 30 workers in his studio, handling the pipe, with the heavy gob of molten glass on the end, like a youth. It is a fish that takes form in glass as I watch him work, and when it is finished and taken to the annealing oven to be cooled over three or four days, there is a respite of no more than an hour before he has started on something new.

"I have no time for anything else," he said. And so the Barbini tradition continues.

ANOTHER TRADITION lives on in Jamey Turner. For him, glass is not to be blown or touched by science but caressed by the hands of those with music in their hearts.

I met Turner, a pixieish man with boundless enthusiasm for just about everything, in the classroom of an elementary school in Fairfax, Virginia. He was there to play for the students, to rub his fingers over the rims of glasses until such offerings as "Ode to Joy" from Beethoven's Ninth Symphony rang through the room in tones more sweet and pure than those of the ocarina.

The instrument is called a glass harp, and there's no one in the world who plays it as well as Jamey Turner. He may use as many as 60 glasses of all sizes, each holding an exact amount of water (the more water, the lower the pitch). His performances in schools are more popular than recess, and there are other times when he performs with symphony orchestras, always astonishing the audience with the music to be drawn from glass.

There have been satellite recordings of "sounds" coming from the planet Jupiter, and, eerily, they are similar to those of the glass harp. I suggested to Turner that maybe there is another, far away, who shares his talent with the instrument. "Oh yes, oh yes, I hope so," he replied before reaching for the distilled water he uses to tune his instrument.

Licked by a blue flame, colored glass melts into petals, pistils, stamens, and stems inside Paul Stankard's Mantua, New Jersey, studio. With glass rods and tweezers, the artist builds arrangements of blossoms, berries, bees, roots, and tiny "root people," then encases them in glass forms up to seven inches high.

For Stankard, shown in a composite photograph with one of his pieces, "the best part is pushing the glass to its limits." More than a third of the time he pushes too far and ends up with distorted pieces or ones marred by bubbles.

A master of the technique called lampworking, Stankard honed his skills by crafting scientific glass instruments. Now he often finds inspiration on walks through the woods near his home. His pieces are hailed for their exquisite detail, from a leaf's imperfection to the tiny yellow hairs on a bee's body. Collectors pay as much as $22,000 to own a glass bouquet suspended in a block of clear glass.

For makers of fine crystal, such as Waterford of Ireland, Orrefors of Sweden, and Corning's Steuben, light is the music of glass—the dance of it through a chandelier, for example, or the soft sparkle of colors in and about a bowl.

It used to be something of an article of faith that a family have at least one nice piece of crystal in the china closet. Remember? It wasn't cheap, but not painfully expensive either, and it had a good feel to it, heavy—at least a 24 percent lead content—but sensual.

DROPS FROM ALFRED UNIVERSITY, ALFRED, NEW YORK

The lead causes light rays to further refract, or bend, separating out colors such as red and green and causing the glass to sparkle.

But the demand for high-quality, handblown crystal has dropped in recent years. In part, this is a matter of fashion and popular taste—but more recently the market has been hammered by world recession and the decline of the U. S. dollar.

"When the dollar is strong, business is terrific," said Redmond O'Donoghue, sales and marketing director of Waterford Crystal. "But when it weakens, we have problems." And so, alas, the famed company, with more than 60 percent of its sales in the United States, is struggling.

Now, in addition to all else, Waterford is working to combat fears of possible health dangers from lead in glasses and decanters.

"Our studies show that one would be more likely to die of alcohol poisoning from the contents than from the lead in the decanter or

glass itself," one Waterford official told me. Nevertheless, the company now applies a polymer coating to the inside of decanters, bringing the level of lead on the surface down to almost undetectable levels.

The company is also marketing a line of less expensive crystal, made not in Ireland but in Germany and Slovenia. Still, Waterford is too much of a giant in the world of quality crystal to give up that market.

The plant in the south of Ireland is heavy with the romance of the time when a piece of Waterford was a *necessary* luxury. Each work produced there continues to be handmade, each fractionally different. And the great engravers are still there, men like Eamonn Hartley, who can put the face of Noah on a piece of crystal and give it all the authority of a biblical injunction.

Another Waterford worker is Tom Jacques, a quiet man with an easy smile. His job is to take the pieces off the belt as they come out of the annealing oven and examine them for flaws. An imperfection, no matter how small, is cause for breakage, and so Tom Jacques spends a good part of his day smashing Waterford crystal. He looked at me and quickly sensed what I was thinking.

"Like to have a go at it?"

The bowl he handed me had a bubble, or "seed," in it; otherwise it would have been priced in a store at $200. And now it was mine to destroy, to hurl and shatter, and I could laugh depravedly while doing it if I chose. It carried into the side of the metal bin with force enough to set up a good noise, part explosion and part crunch, followed by a rain of joyful, and most satisfying, tinkling.

Tadpoles of glass called Prince Rupert drops are both tough and fragile. Bang them with a hammer, and they won't break. But snip their tails, and they shatter.

The curiosities were named for a 17th-century prince who saw them at a Bavarian glassworks and then impressed England's King Charles II with a demonstration. The drops are crude forms of tempered glass made by dripping molten glass into a bath of water or oil. This cools the exterior faster than the interior, creating surface compression that lends strength. Stress lines are revealed here by cross-polarized light filters. A drop's tail is its Achilles' heel. There a mere scratch will set off an explosive chain reaction of fractures.

Nowadays tempered glass—sometimes produced chemically rather than by quick cooling—can withstand pressure up to 22,000 pounds per square inch. It finds use in eyeglasses, oven cookware, basketball backboards, and car windows that shatter instead of breaking into lethal shards.

NOT ALL THE GLASS TECHNOLOGY that touches our lives is ultramodern. Consider the lowly lightbulb; 1.8 billion are manufactured each year in the United States, and the machine that makes them is surprisingly aged—it creaks and groans—but has not yet been surpassed. It stands, you might say, as a paradigm for those of us of a certain age.

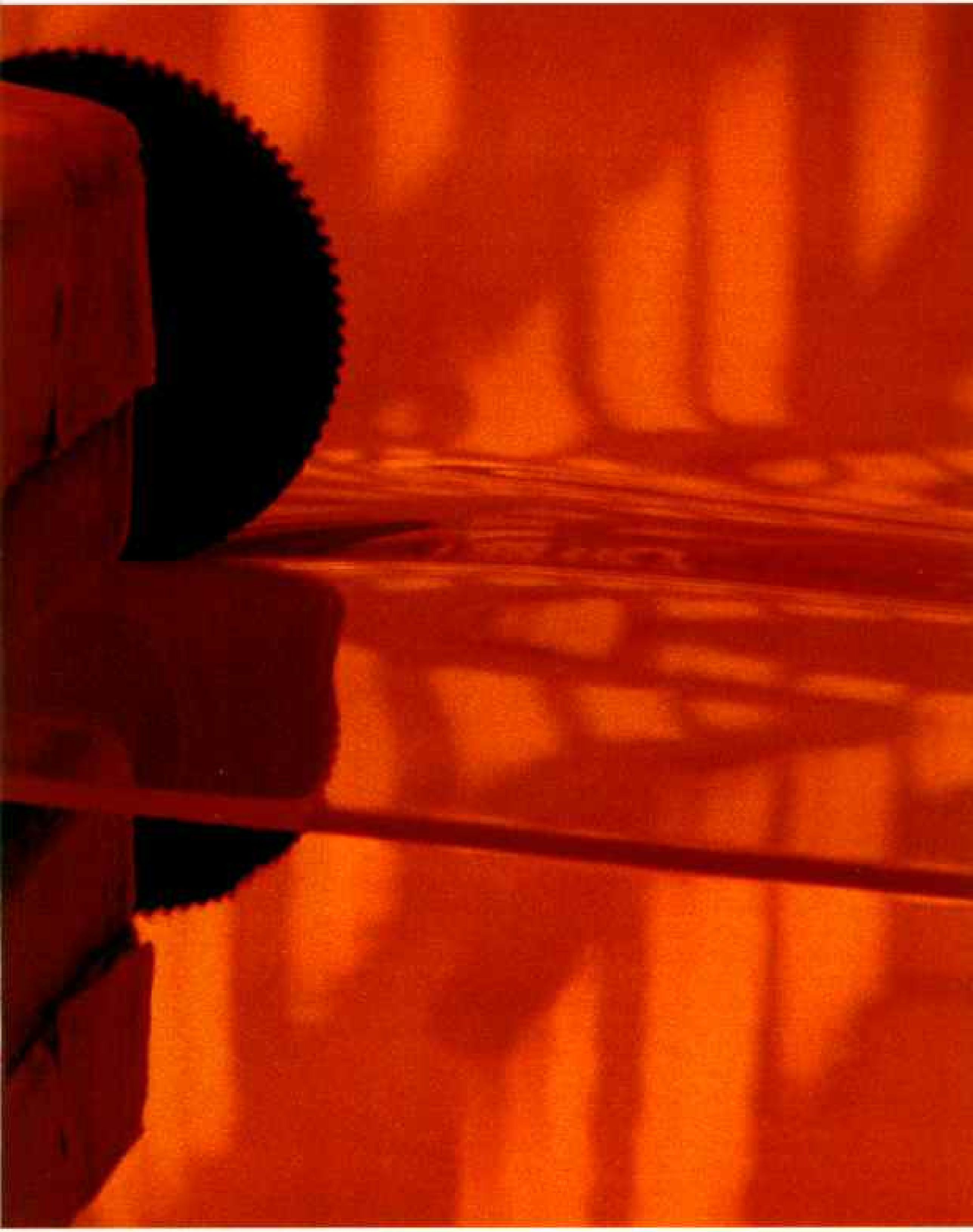
At the turn of the century most lightbulbs were handblown, and the cost of one was equivalent to half a day's pay for the average worker. In effect, the invention of the ribbon machine by Corning in the 1920s lighted this nation. The price of a bulb plunged, and the pale yellow light of those early filaments flickered in households from coast to coast. Small wonder that the machine has been called one of the great mechanical achievements of all time.

And yet it is invested with nothing so much as wondrous simplicity: A narrow ribbon of molten glass travels over a moving belt of steel in which there are holes. The glass sags through the holes and into waiting molds. Puffs of compressed air then shape the glass. So it is that the envelope of a lightbulb is made by a single machine at the rate of 66,000 an hour, as compared with 1,200 a day produced by a team of four glassblowers.

The ribbon machine is not without its drawbacks. "For every 10,000 pounds of molten glass that goes into the machine, only 3,500 is used," said Jeffrey Hoffman, operations manager at Osram Sylvania in Wellsboro, Pennsylvania. The rest, called cullet, is recycled back into the furnace.

Corning no longer makes bulbs for general use, but its ribbon machines live on at the Wellsboro plant, which it sold some years

A thick syrup of hot glass floats on a bath of liquid tin at a PPG Industries factory. Inside a chamber heated to 1500°F, the glass is sized to a smooth eighth-of-an-inch layer. Introduced in Britain in 1959, this float-glass method has become the most widely used means of producing flat glass.



ago. This is where it all began, and where it continues—all the clanking, clunking, and hissing of that amazing invention, and all the tens of thousands of paper-thin bulbs (twenty-thousandths of an inch) tumbling onto the conveyor belt.

And watching it all, you might want to applaud the breakage rate of only between 3 and 4 percent. Or you might wonder, as I did, that 7,000 bulbs can be packed naked in a single wooden carton with no protection but a light coating of lubricant on each bulb.

THE SECRET of glass's versatility lies in its interior structure. Although it is rigid—and thus like a solid—the atoms are arranged in a random, disordered fashion—characteristic of a liquid. In the melting process, the atoms in the raw materials are disturbed from their normal position in the molecular structure; before they can find their way back to crystalline arrangements, the glass cools.

This looseness in molecular structure gives the material what engineers call tremendous "formability" and capacity for dissolving. "You can cast a huge mirror or draw out glass as a fiber," said Dr. Prindle, the retired Corning technology expert. "And you can dissolve almost anything in it, and in great quantities. The ability to accommodate allows technicians to tailor glass to the need.

"To make a brilliant, sparkling glass, add lead oxide or barium oxide to the basic sand-soda-lime mixture; for a heat-resistant glass, throw in boric oxide; for green sunglasses, add chromium and copper."

Scientists continue to experiment with new mixtures. Corning manufactures 750 different glasses and glass-related products, keeps hundreds of thousands of glass formulas on record, and each week evaluates hundreds more. There, men and women sit in small rooms facing large computers and electron microscopes and other exotic instruments, all probing the elusive atoms.

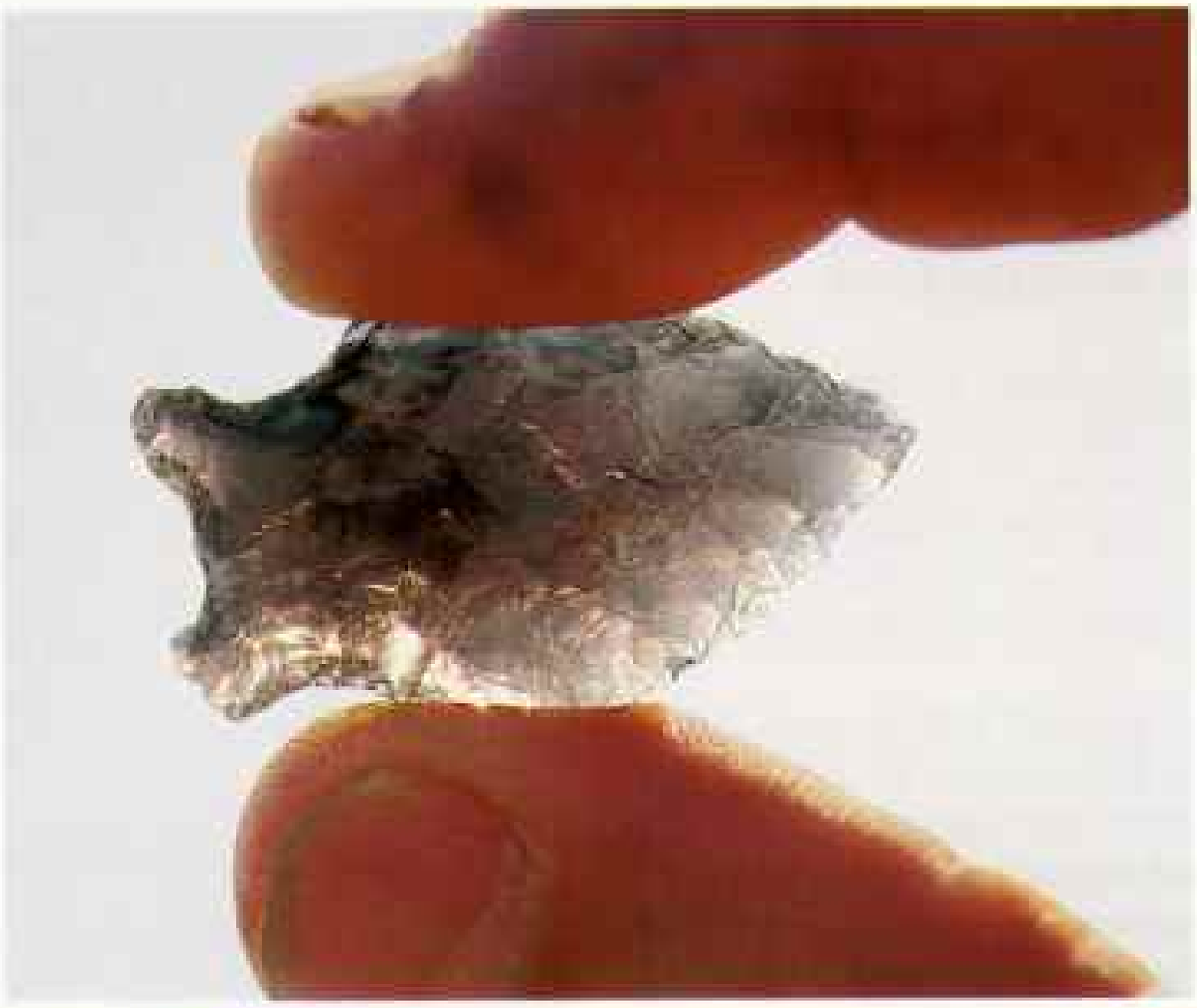
"We can now understand glass better," said Michael Teter, a research fellow in engineering at Corning. "What has always been missing is a full knowledge of what goes on at the molecular level. Less than one in ten projects involving new uses for glass succeeds. Now at least we have a chance of knowing why things go wrong."

Mike Davies is a London architect, a member of Richard Rogers Partnership, designers of the new Lloyd's of London building. In that edifice Davies and his colleagues had opportunities to test their imaginations with applications of special glasses. The core of the building is a glass atrium, whose 16-story facade is fashioned of 14,350 square yards of glass. Into that glass were rolled thousands of prisms, to forge diamonds out of the sunlight and add sparkle to that towering house of indemnities.

But Mike Davies sees even more dramatic buildings, using molecular chemistry. "Glass is the great building material of the future, the 'dynamic skin,' " he said. "Think of glass that has been treated to react to electric currents going through it, glass that will change from clear to opaque at the push of a button. That gives you instant curtains. Think of how the tall buildings in New York could perform a symphony of colors as the glass in them is made to change colors instantly."

Glass as instant curtains is available now, but the cost is exorbitant. As for the glass changing colors instantly, that may come—

Bands of volcanic glass glisten within Panum Crater in California's Inyo National Forest. Known as obsidian, the glass is darkened by small amounts of iron. Formed when hot lava quickly cools after oozing to earth's surface, obsidian is the most common natural glass. Its chemical composition is similar to granite; both contain a large amount of silica—the basic ingredient in all glass.



Interspersed are gray bands of pumice, a frothy glass created when lava erupts from a volcano and then cools with gas bubbles still trapped inside.

Native Americans flaked obsidian into tools, such as this arrowhead found near Wyoming's Jackson Lake. Today obsidian is sometimes cut for jewelry, while pumice is used as a scouring material.

but engineers are not yet prepared to transform, say, the John Hancock Tower in Boston into a pillar of green for St. Patrick's Day.

Companies do offer a range of windows designed to conserve energy. There are reflective coatings and other elements in glass to control the amount of sunlight and heat coming into a room. Mike Davies' vision may indeed be on the way to fulfillment.

THERE ARE MANY FAMILIES of glass, among them glass ceramics. They are made stronger than ordinary glass by heating special glass compositions to form patterns of orderly molecules. There is one called Macor, developed by Corning, and it is strong enough to be worked on a lathe, to have nuts and bolts fashioned of it, and to serve as window frames in the space shuttle.

There is another, Dicor, also by Corning, used to make dental crowns with an aesthetic effect never before achieved. It is stronger than dental porcelain, plaque resistant, and highly translucent.

Glass fiber optics grew from a challenge laid down in 1966; make a glass pure enough to allow at least one percent of a light pulse to travel one kilometer (.62 mile) through it. At the time, the best fibers could carry the light only 30 feet.

The answer was found in extremely pure, flexible, coated glass fibers. Today the pulses can be transmitted more than 75 miles before requiring a repeater device. Fiber-optic systems—using lasers no larger than a grain of sand—can transmit 32,000 times as much information as the equivalent amount of copper wire. United States, Japanese, and Middle Eastern investors are now planning a one-billion-dollar project—the world's longest undersea fiber-optic cable, stretching from the United Kingdom to Japan via the Indian Ocean. Five fiber-optic cables already link Europe and the U. S. Another three connect the West Coast with Japan.

Fiber-optic technology has proved a boon to surgeons and patients too: The thin and flexible devices are inserted into the body to give doctors living pictures of internal organs.

Glass also helps victims of liver tumors. Beads one-third the thickness of a human hair carry radiation directly to the tumor. According to co-inventor Delbert E. Day of the University of Missouri-Rolla, the radiation is delivered in glass microspheres; these are injected through a catheter into the artery that supplies blood to the liver.

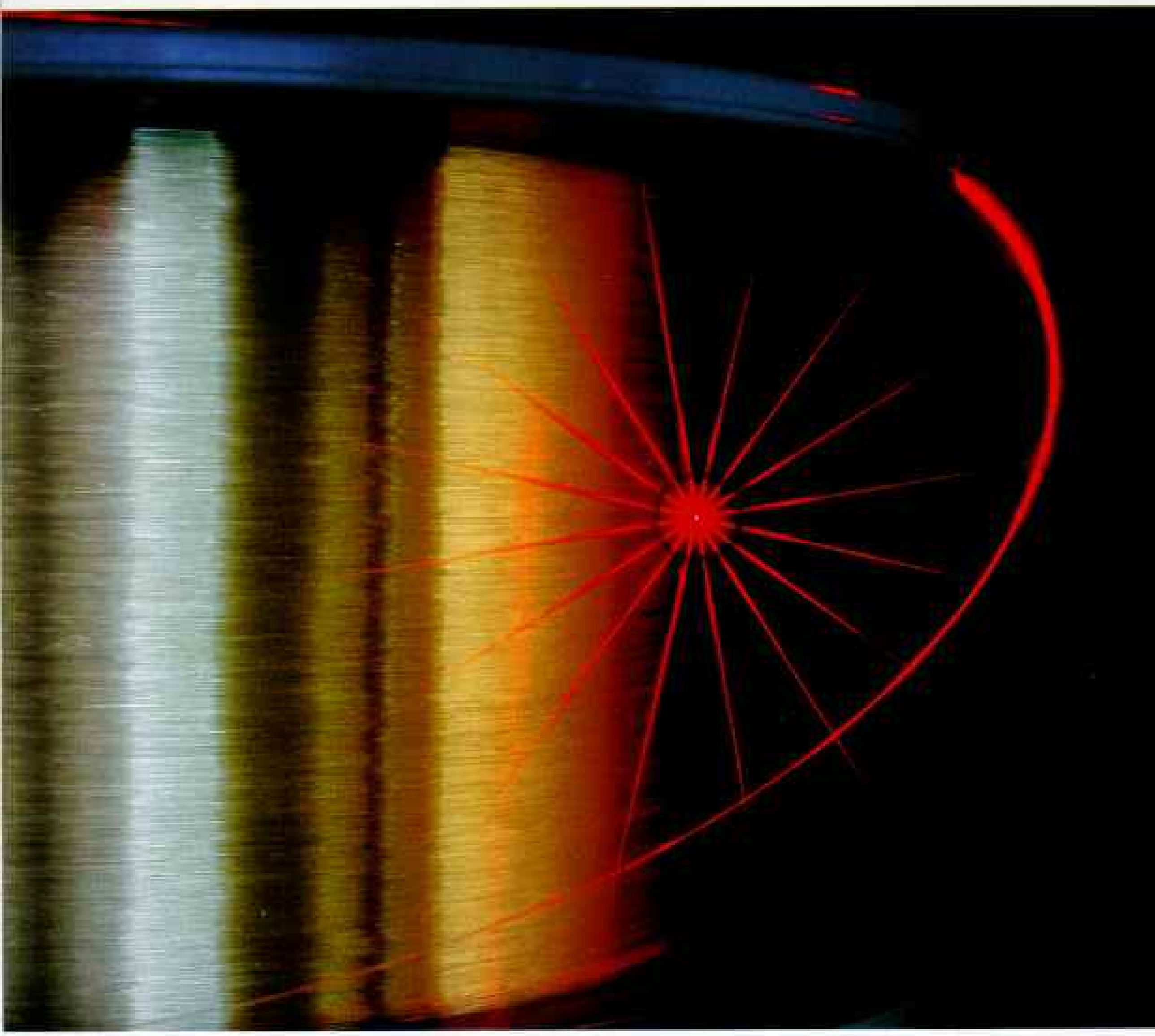
"In this way," said Dr. Day, "the radiation can be concentrated in the area of the tumor and deliver four or five times the amount provided by routine methods." The beads usually lose all radioactivity in two or three weeks, after which they remain in the liver forever. The procedure is now used in Canada.

Much research focuses on finding methods of making glass almost totally resistant to heat and expansion. Would it be possible to make an automobile engine out of such glass? As it would conduct little or no heat, the need for a coolant might be eliminated. I put the question to Dieter Krause, chief of research for Schott Glaswerke of Germany. He seemed taken aback.

"I can't imagine that," he replied. "However, new highly porous glasses are being developed, and under proper management, they could be used as a filter material in some engines."

Schott's main plant, in Mainz near Frankfurt, pushes down to

Light from a laser spirals through more than a mile of glass thread wound on a spool. Carrying vastly more information than copper wires, glass fibers are speeding communications. A fiber-optic network allows ten rural Oklahoma schools to share classes through two-way television. Without the system "I wouldn't have gotten to take advanced courses," says Turpin High School senior Lisa Isaacs, watching her English teacher beam in from 20 miles away.



*T*inted by uranium, a yellow dessert bowl glows green under ultraviolet light. The color and Wildflower pattern were popular in 19th-century America, when mass production made glass widely affordable. Machines pressed glass into molds for plates, vases, bowls, and butter dishes.

the Rhine River; from it have come major advances in glass. More than a century ago Otto Schott was one of the first to vary density and refraction in glass by adding ingredients such as barium and phosphoric and boric acids. The company went on to develop many optical and specialty glasses. Today it makes not only bottles for a baby's formula but also windows of radiation-shielding glass, weighing as much as two tons each, for use in nuclear research.

Of all the optical pieces made by Schott, none match in size the

"It's like hearing angels sing," says Jamey Turner, who serenades children with his glass harp at the annual White House Easter Egg Roll. He creates celestial sounds by rubbing his moistened fingers around the rims of water-filled brandy snifters. Distilled water works best. Turner favors ordinary glassware because of the short duration of the sounds it makes. Leaded crystal rings much too long and can produce headaches, he says.

one now being prepared by the company for the European Southern Observatory, a consortium of eight European Community nations. It is the first of four mirrors for what will be the world's largest optical telescope. When finished, the instrument will be placed atop 8,740-foot-high Cerro Paranal in the Atacama Desert of Chile, a site where most nights are awash in brilliant clarity.

Each mirror, made of a glass ceramic called Zerodur, will be nearly 27 feet in diameter and weigh 24 tons. It has been said that this will be the most stupendous work in glass ever done.

"Ever done, yes," agreed Alfred Jacobsen, a Schott official and an expert on optical glass. "But you must understand that it is very difficult to handle such a large piece, and it must be transported a long way."

"Are you afraid it's going to . . . ?" (It is difficult to speak of breakage to those who are in glass for a living.)

"There *is* concern," Mr. Jacobsen replied, going on to point out that while the mirror would cover the floor space of a double

garage, it will be less than seven inches thick. Such a monumental production is itself a challenge. After the piece has cooled from its 2200°F pouring temperature to a more manageable 1500°F, it is moved to an annealing oven where it will remain for four months, until it cools to room temperature. Perhaps the most heart-stopping moment in the process occurs when the mirror is removed from the mold. The workers are silent in concentration and hardly notice that the temperature in the room has reached 120°F. A 70-ton crane has moved into position above the mold, and from it drop lines attached to vacuum cups. And so the mirror is held there like a hovering, massive spaceship while the mold is dismantled.

In the end, after 23 months, the mirror will be 70 percent crystalline and completed. It will travel by ship to Paris, where French technicians will polish it, then voyage to Chile. Finally, it will go up the mountain in a specially made vehicle with 16 axles. The first one of the four is expected to be ready in 1995.

THERE HAS BEEN a sense of mission in the casting hall at Mainz. It seems as if the workers share an awareness that when the four mirrors are in place, arranged on the mountaintop and programmed to function separately or together as one telescope, astronomers will be able to study distant objects in more detail than ever before.

As glass can reach out to the stars, it can also carry our nightmares deep into the earth. In the piney woods of South Carolina, technicians are preparing to make glass with radioactive wastes. This glass will be jacketed in steel and hidden away forever—one answer to the dilemma of what to do with dreaded nuclear refuse.

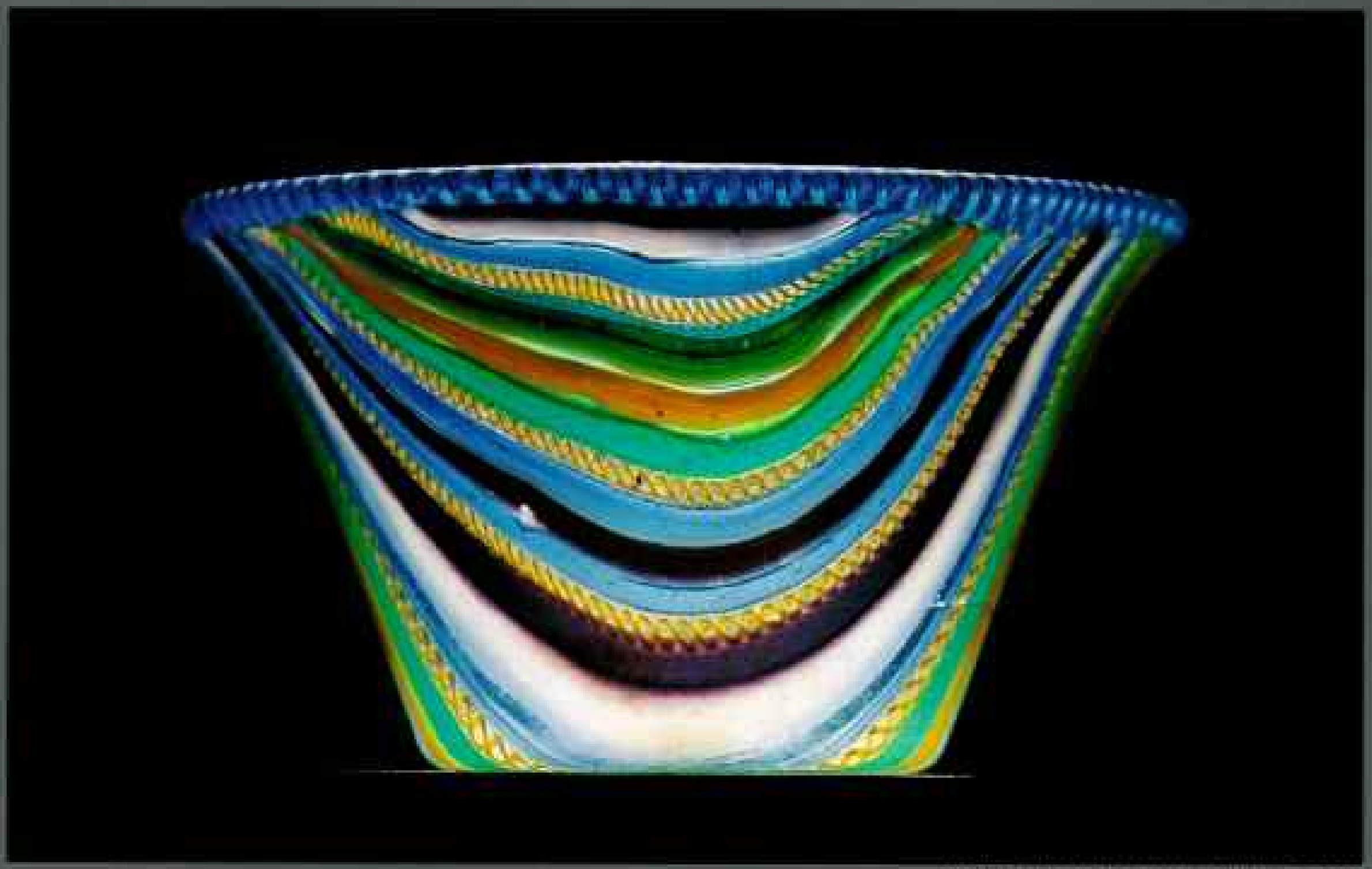
The ability of the basic ingredients of glass to dissolve almost anything, and in large quantities, makes the procedure possible. And because glass retains its physical and chemical characteristics almost like volcanic rock, a block of the hazardous nuclear-waste glass can be encapsulated in a stainless-steel canister and buried in the ground without fear of leakage. This method has already been put to use in France, Belgium, and the United Kingdom.

In the U. S., plans are moving ahead to vitrify some of the 34 million gallons of highly radioactive wastes at the massive—300 square miles—Savannah River Site in South Carolina. Plutonium 239 and tritium have been produced there for use in atomic weapons since the 1950s, the height of the Cold War. The site holds five heavy-water reactors.

Of the 34 million gallons of waste, 3.4 million emit high-level radiation, mainly from cesium and strontium isotopes. This deadly muck now has the consistency of peanut butter. A building in which to vitrify the material has been constructed, using 69,000 cubic yards of concrete and 13,000 tons of steel. The facility will be fully automated, for this truly will be a glass to see through not only darkly but at a distance.

The radioactive material will be mixed with fine particles of borosilicate glass and fed into a *(Continued on page 69)*

Sweeping forms of dazzling blown glass are the signature of Dale Chihuly, one of America's best known living glass artists, who has extended the possibilities of the medium. Though unable to blow his own pieces since losing an eye in a 1976 auto accident, Chihuly directs a team of artists at his Seattle studio. Says artist Harvey Littleton, an early mentor: "He's not pushing the bow across the fiddle, but he's responsible for the music."



ALL PHOTOGRAPHED BY THE CORNING MUSEUM OF GLASS

From Pliny to Tiffany and Beyond

Glass ribbons make up a Roman masterwork less than four inches wide. In this piece painstakingly crafted strips of glass were fused and shaped in several stages.

Ancient casting methods were gradually discarded after the first century B.C., when the Romans developed glassblowing. For the first time, glass became common. Craftsmen blew pieces in a variety of shapes and sizes—as funeral urns or translucent containers to store food and hold ointments. "For drinking vessels, glass has quite superseded the use of silver and gold," wrote the Roman scholar Pliny the Elder in the first century A.D.

Ten centuries later, an Islamic artist crafted an eggshell-thin ewer (right) by covering a clear blown piece—now weathered white—with molten green glass, then carving an intricate animal scene.

PHOTOGRAPHED AT THE CHARLES HOSMER MORSE MUSEUM OF AMERICAN ART, WINTER PARK, FLORIDA

From flamingo feathers to the folds of a woman's dress, U. S. artist Louis Comfort Tiffany achieved special effects by working color and texture into his stained-glass pieces while the glass was still hot.

"What drove him was nature and trying to express nature in glass," says Alice Cooney Frelinghuysen, a curator at the Metropolitan Museum of Art in New York City. Teams of craftsmen usually executed Tiffany designs such as this leaded window, first displayed in Chicago in 1893 and later at his Long Island estate.

Like Tiffany, the French artist Emile Gallé looked to nature for inspiration. A leader of the art nouveau style, Gallé achieved complex effects by engraving fused layers of blown glass and applying designs to the surface. Ghostly cicadas, butterflies, and moths seem to fly inside his pieces. In his 1903 "Dragonfly Coupe" (above right) the insect appears to escape from the glass.

Using cobalt and other metals,

BOTH PHOTOGRAPHED AT THE CORNING MUSEUM OF GLASS

Flavio Poli created layers of color that stressed the smooth lines of his vases. Poli worked near Venice on the island of Murano, a glassmaking center since the 13th century. Exuberant, colorful pieces characterized his work and that of fellow 1950s Venetian designers.

In recent years cold glass sculpture has led to a new flowering of artistic expression. In the 1992 Olle Alberius sculpture "Cleopatra," the breasts bring into focus a cloudy sky. Craftsmen at the Orrefors glassworks in southern Sweden cut the figure from a block of leaded crystal and dipped it in acid to give it a clear finish.

Rainbows of colors burst from finely finished slabs of optical glass that make up many of Briton Peter Aldridge's pieces, including "Amadeus" (below right). "There's something very ethereal about the transparency of glass," says Aldridge. "It's almost mystical, almost a fourth dimension." A former designer for Steuben in Corning, he makes use of refracted light, designing precise and angular pieces with the help of computers.

Czeslaw Zuber, a Polish artist living in Paris, uses hammers and sandblasting tools to shape blocks of industrial glass into savage heads—such as the 1988 piece from his series "Les Bêtes"; he later applies the color. Glass "allows you to dive into another world very quickly," says Zuber. "It's a magical material."

PHOTOGRAPHED AT ORREFORS, ORREFORS, SWEDEN (ABOVE), AND THE CORNING MUSEUM OF GLASS

PHOTOGRAPHED AT THE CORNING MUSEUM OF GLASS

(Continued from page 61) melter where it will cook at a temperature of 2100°F. And then, destined to harden into shiny black glass, it will be poured into steel canisters for burial, possibly in a mountain in Nevada.

Test runs of the equipment began in 1990 and are expected to continue into 1994, when the actual melting will start. To process the current inventory of high-level waste will require more than 15 years.

DROVE AWAY from the Savannah River Site and headed north, to the place in Tidewater Virginia where I was born. There is a church there with a stained-glass window whose memory has stayed with me through all my life.

Of all the kinds of glass art, none is more widespread and enduring than stained glass. It is found not only in great cathedrals but also on the doors of shower stalls and as the shades for night-lights. It has also become an important architectural material, incorporating the glorious union of sunlight and colored glass.

The Abbé Suger, who in the 12th century rebuilt the church of Saint-Denis outside Paris, was among the first to recognize the ability of glass to brighten mood and perception, to allow us to move outside our physical world, "urging us onward from the material to the immaterial."

The process for making stained-glass pieces has remained much the same for centuries. Color is brought to the glass by adding different metallic oxides to the basic mixture of sand, soda, and lime. Amber, for example, is created by adding silver; an exquisite gold-pink glass contains real gold. Pieces of the colored glasses are cut to fit a pattern—say, a life-size depiction of the Venerable Bede for a church window—and then are joined with the use of lead cames, or rods, soldered together. The process demands not only the vision of art but also technical expertise—craftsmanship. Stained glass made in this traditional way is expensive, as much as a thousand dollars a square foot.

After blossoming in medieval times, stained glass declined in popularity, then came back to prominence in the late 19th century. Great artists such as Matisse, Chagall, and Braque worked with the material, but it was an American, born in 1848, whose name for me came to stand for masterworks in stained glass. He was Louis Comfort Tiffany. His windows, lamps, and other pieces glow with translucent colors, and they stand among the greatest glassworks ever produced.

The window in my childhood church is of the opalescent blue of a Tiffany work, but it isn't one. I had come back to the church with an awareness that there is a lot of bad stained glass upon the land today, glass to inspire nothing other than disdain for poor quality.

But when stained glass is well-done, when light plays on the piece in a way to draw reverence from the soul, then that is cause to sit and wonder and think. I thought of a now deceased colleague of mine on this magazine.

He once wrote of Chartres Cathedral and its magnificent windows, referring to the medieval French church as "a vast prayer in glass. . . ." In the church of my childhood, there is nothing to compare with that, but I think my friend would agree that this stained glass before me now is, at the least, a moment of grace. □

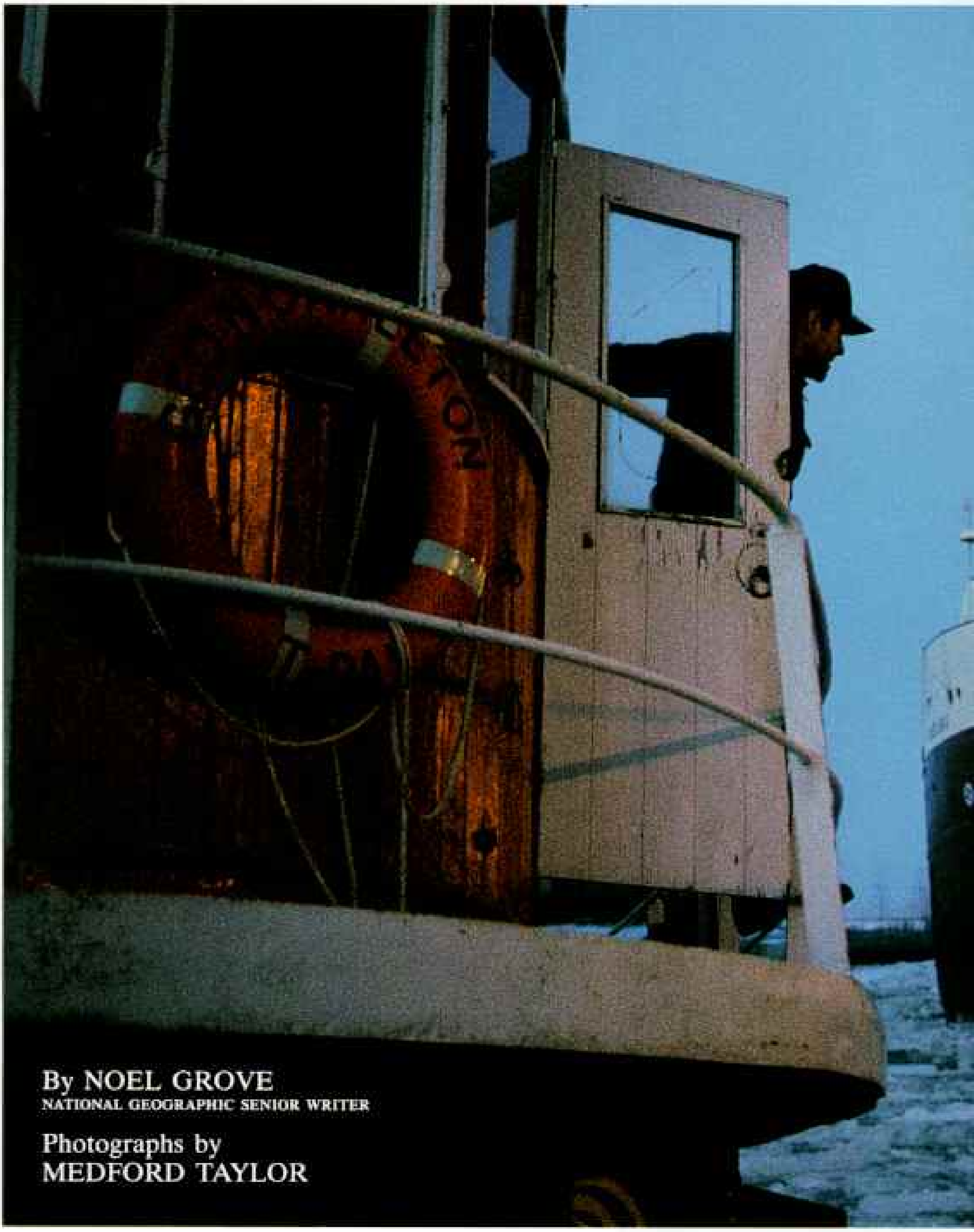
"Tiffany's work is of a dumbfounding versatility," a critic wrote after seeing a show of the artist's Favrile glass designs.

Drawn to the iridescence of ancient glass, Tiffany worked to duplicate the effect. He achieved it with his popular jack-in-the-pulpit vases by treating the hot material with metallic salts. Though stained-glass windows were his passion, less costly lamps and vases reached a far broader audience.

A trained painter who ran his own interior decorating business, Tiffany was influenced by the flowing, graceful lines of European art nouveau. The style adapted especially well to the flower-form vases handblown at his furnaces in Corona, New York. An admirer wrote: "He is imbued . . . with a desire not merely to add to the world's beauty, but to bring that beauty within the reach of the public."

THE SUPERIOR

Looming large on Superior, the world's biggest freshwater lake, the 730-foot Canadian laker Rimouski

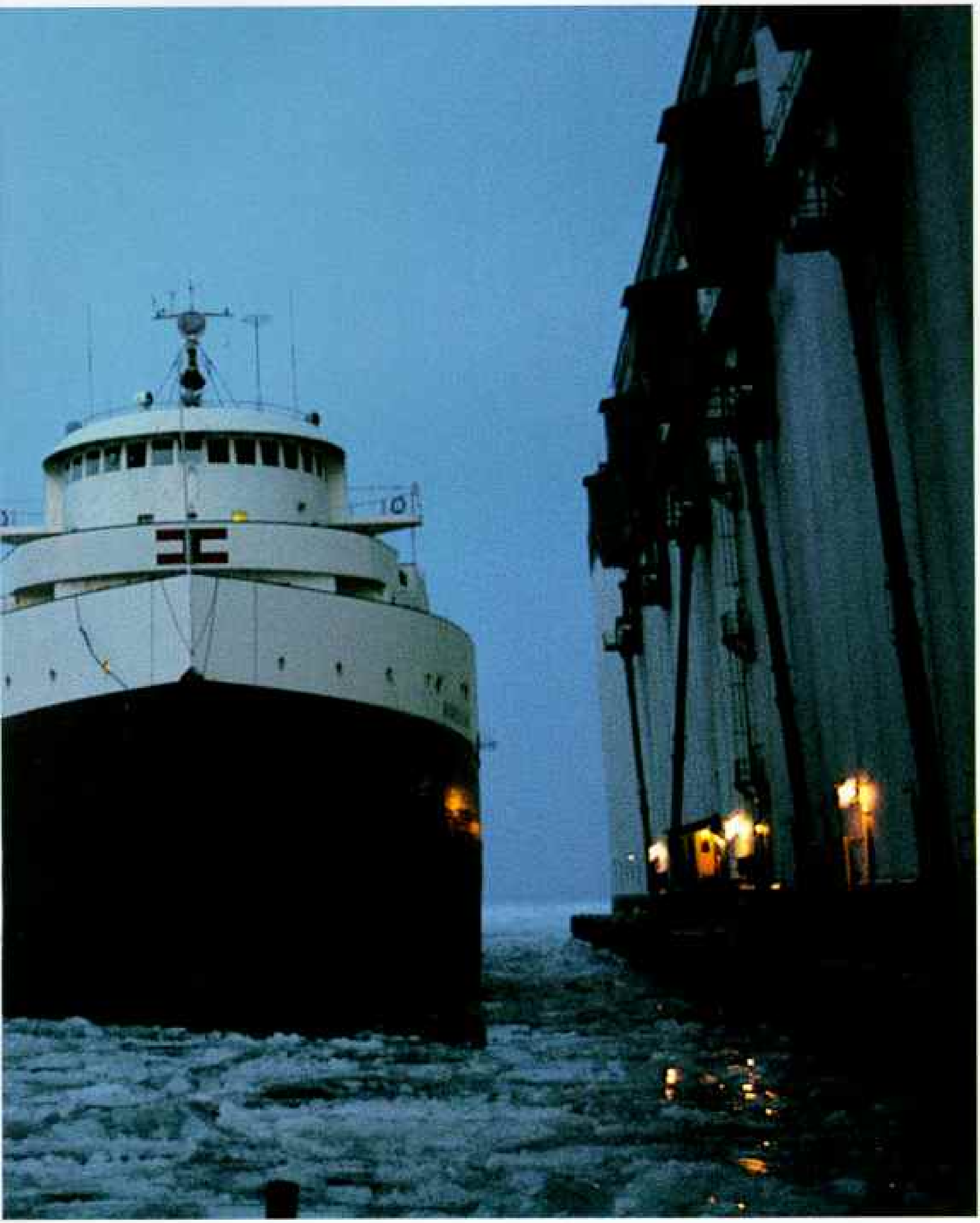


By NOEL GROVE
NATIONAL GEOGRAPHIC SENIOR WRITER

Photographs by
MEDFORD TAYLOR

WAY OF LIFE

slips through ice in March to load the year's first wheat from Thunder Bay, Ontario.



Exposing its gentle side on a frosty December morning, Superior laps at the palisades beneath retired Split Rock Lighthouse on the Minnesota shore. The lake's mood can darken quickly. Fast-moving low-pressure cells spawn ocean-like gales with 30-foot waves on what one captain calls "the world's most dangerous body of water." Its floor is littered with some 350 shipwrecks.

I FIRST LAID EYES on Lake Superior and the big country around it more than a decade ago. I drowned myself in its pleasures: fishing for trout, hunting for mushrooms, picking berries in its pine-scented air.

On my frequent returns to the lake country, I have been heartened to find that it remains as I first knew it, uncommonly clear, still heavily forested, and bathed in exquisite stillness. You can hear a lynx scream, follow the tracks of wolves hunting deer, or sail along rock-strewn beaches without seeing a soul. And you may be awakened in the night, as I was in my sleeping bag, by a woodland caribou—vanished elsewhere at those latitudes—splashing through a quiet inlet yards away. I was grateful for the wake up; overhead the northern lights flickered, like wind rustling the tent of the sky.

"We Indians feel this lake is alive," said

Billy Blackwell, who traces his ancestors to the Ojibwa who loved this land. We sat on the lake's Minnesota shore, listening to waves murmur against the rocks. "It provided our grandfathers with food to eat, water to drink, water to bathe in," said Billy, who wears a dark ponytail and gazes across the water. "It has a soul."

It is easy to understand why the Ojibwa fought the Sioux for rights to Superior's often bitter cold shores. French Canadians who paddled Superior's mountainous blue waves in birchbark canoes called it *le lac supérieur*, simply referring to its location above the better known Great Lakes Huron and Michigan. Superior it remains, in any translation.

Today some 600,000 people live along the lake's 1,700-mile shoreline (map, page 77), but more than half are clustered in Thunder Bay, Duluth, Marquette, and Sault Ste. Marie. That leaves plenty of real estate for wildlife, unspoiled views, and water so clear that as one fisherman told me, "A mile from shore I just dip out a cupful and drink it."

Superior is the broadest freshwater lake in the world. It could swallow Scotland with 1,300 square miles to spare or tuck within its shoreline New Hampshire, Vermont, Massachusetts, Rhode Island, and most of Connecticut combined. Something set adrift could float 160 miles across the lake from Rossport, Ontario, to Munising, Michigan, or nearly 400 miles from Duluth in the west to the locks at Sault Ste. Marie. Waterlogged, it could sink 1,333 feet at the deepest point.

That's only a quarter as deep as Baikal in Siberia, but the volume of Lake Superior is still awesome. Tipped and emptied like a washbasin, it would cover both North and South America with a foot of water. Those who live on its shores boast about its size as Texans boast about their state, and they complain about the weather as farmers do.

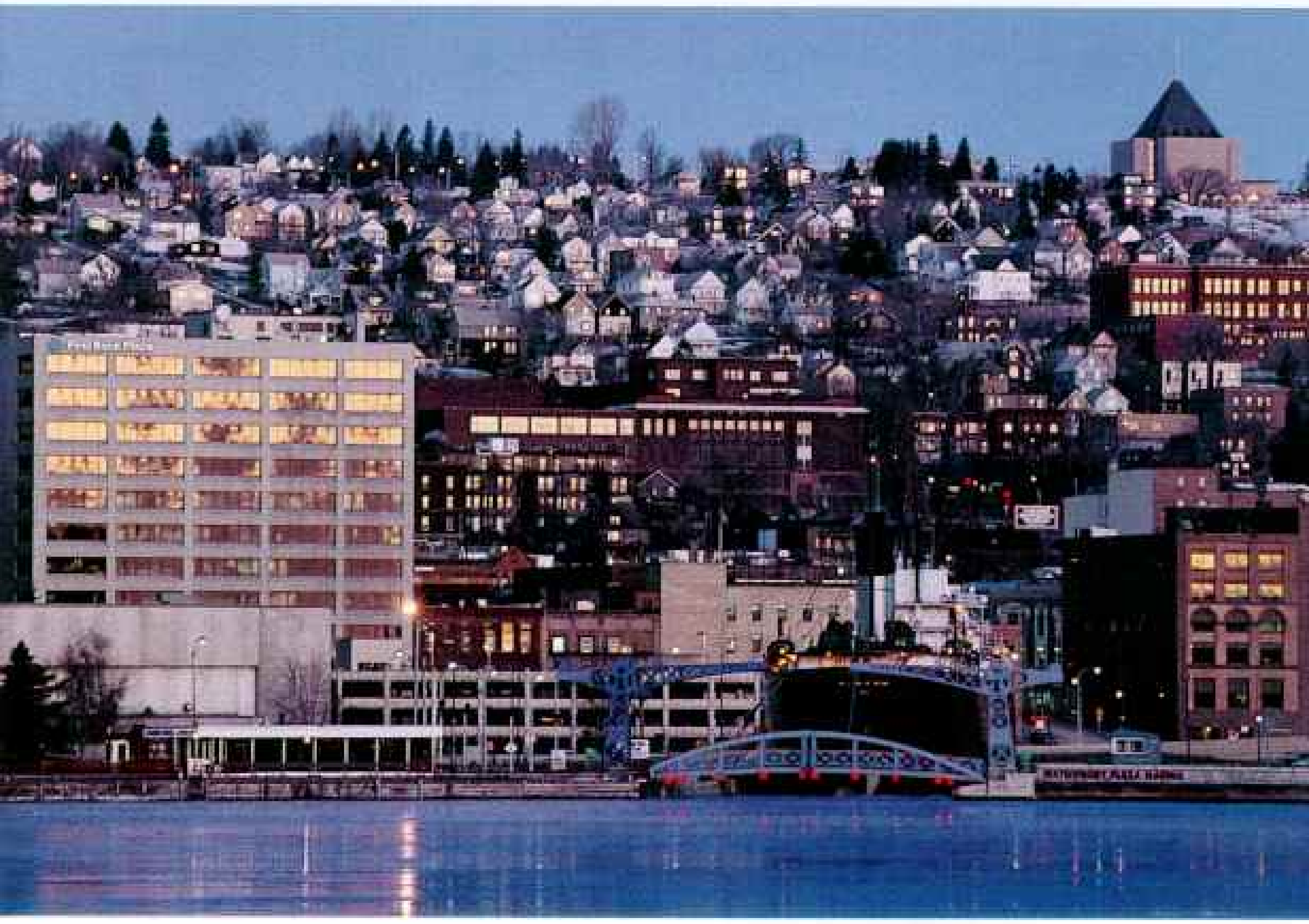
"We have large areas as close to unspoiled wilderness as you'll find anywhere in the lower 48 states," said a proud Minnesotan.

"Right there on the number three tee sat the biggest lynx I've ever seen," bragged a golfer at Marathon, Ontario.

"It has the clearest and coldest water of any of the Great Lakes," said Christine Olsenius, former vice president of the Lake Superior Center in Duluth, a freshwater education center. And maybe the wildest, according to Jim Marshall, mining-equipment executive and "wreckie," a student of lost ships. "There are 350 known wrecks. Fall storms create 30-foot waves."

If that seems ocean-like, the events that created Superior in fact nearly made it one. "We believe a volcanic plume came from deep

Son of a Swede, Louis During, 84, of Superior, Wisconsin, reflects on a life spent trapping coyotes, repairing railroads, and loading grain elevators. His pioneer father's name was Jonsson, but "there were so many Jonssons in the logging camps, he just changed his name."



within the earth a billion years ago and split open the crust," said John Green, a geologist at the University of Minnesota, Duluth. "We're not sure why it didn't continue."

The hook-shaped rupture in the middle of the continent might have placed Wisconsin and parts of Michigan and Minnesota where the Gulf of Mexico is today. Detroit's present location would have been open sea had the rift not mysteriously healed.

Fifteen miles west of Duluth John led me through thick young aspens and brambles up a slope to a rocky outcrop. Halfway up the slope, blocks of basalt five feet thick protruded from the earth like great, gray buckteeth. "This is some of the earliest lava," he said. "It flooded out for millions of years. When it stopped, the sheer weight of it created a depression."

Water levels rose and fell with glaciation, and the lake eventually settled into the configuration of a wolf's head. The Keweenaw Peninsula on the south shore opens the animal's mouth. Isle Royale, 45 miles long by 9 miles wide, is the perfect slanted eye. Nipigon Bay at the top forms a pricked-up ear, and to the southwest the lake narrows to a long nose sniffing at Duluth.

"PEOPLE LIKE THE CHALLENGE of living up here," said Cindy Hayden, who with her husband, Paul, publishes *Lake Superior Magazine* in Duluth. "In October we got a yard of snow, the kind of thing that would paralyze most parts of the country. We just dig out."

Winters are long, but seem longer because real summer is just a blown kiss. The warmer weather spreads a green blush over land that is 90 percent forested. The rest seems dominated

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Photographer MEDFORD TAYLOR was formerly on the staff of the *Virginian-Pilot*. As a free-lancer he captured Australia's "Simpson Outback" for the April 1992 GEOGRAPHIC. His work has also appeared in NATIONAL GEOGRAPHIC TRAVELER.

GREATEST OF THE GREATS

All the other Great Lakes combined wouldn't fill this inland sea, which holds a tenth of the world's liquid fresh water. The French called it* le lac supérieur, *the upper lake. Duluth (left) is a sweet sight to mariners who sail from as far as Asia to pick up cargo.

by wildflowers, with riots of lupine, hawkweed, and buttercups.

The color, summer mildness, and wild flavor bring millions of visitors. Winter squeezes out all but a sprinkling of skiers and snowmobilers. By October the northland belongs again to the true lake people.

"This country is not for everyone," said Wendy Bell, former mayor of Marathon, midway along the north shore. "It's expensive—fuel costs especially—and if you don't like winter, you wouldn't be caught dead here."

"I came because it's not crowded," said Gary Cholwek, a fisheries biologist in Wisconsin who moved from Washington, D. C. Would it go the way of other unspoiled landscapes—discovered, then loved to death?

"Forty below," Gary said with a wink, "has a way of keeping out the riffraff."

Memory fails where cold weather is concerned. This isn't too bad, I told myself, assessing the bite in the air as I crunched over snow outside Duluth's airport one January evening. I opened my mouth and took a quick breath to ask directions . . . and gagged on the cold. When I'd gotten my voice back, and my directions, I asked how cold it was. "I don't know," the young woman shrugged, "between 10° and 30° below [Fahrenheit]."

It had actually crawled above zero at midafternoon, I learned later. It stayed cold the next day as I watched a dog-pull contest at Duluth's Lester Park. Dress for the event was muffin-man clothes and Mickey Mouse boots. Infants in strollers peered out of puffy down-filled fabric. All ages attended to watch a dog-pound mix of canines lunge against the traces and pull a weighted sled 16 feet.

Contestants included collies and pit bulls. A pony-size Irish wolfhound dragged off a thousand pounds as though he were strolling to his food dish.

My favorite was a 35-pound wheaten terrier named Tobie that looked like a fluffy leash decoration and pulled like a Clydesdale. Rear paws digging into the snow, back arched, she towed inch by inch a 420-pound sled.

"I grew up with sled dogs, but I don't have

room for them now," said Tobie's owner, Jean Frogner. "So I taught Tobie to pull. It's all just an excuse to get outdoors."

Yards away from the pull was the finish line of the Grand Portage Chippewa John Beargrease Sled Dog Marathon, a 500-mile race commemorating a late 19th-century Ojibwa mail carrier. Both the pull and the race were part of Duluth's four-week Winter Sports Festival. Every community seems to have one.

At Houghton, Michigan, home of Michigan Technological University, students race on snowshoes and speed skates and in homemade dogsleds, with students as dogs. I'd never before seen volleyball played with mittens on snow-covered courts. (No spiking allowed—the cold-hardened ball can deliver a knockout blow.) I walked across campus with Heidi Meyers as students put last-minute touches on house-size snow sculptures.

"I was set to go to school in Florida," said Heidi, a sophomore from Maryland majoring in chemical engineering. "But I came up here to help my older brother move in, and I was impressed with the friendliness and the sense of personal safety in the community."

At the Bon Soo Winter Carnival at Sault (pronounced Soo) Ste. Marie, Ontario, I watched participants in the Polar Bear Swim cook in a mass sauna, then run 50 yards to dive into a hole in the ice of the St. Marys River. A submerged steel cage protected them from being swept under the ice by the current. Cocky grins lit their faces on the way in; desperation marked their scramble out.

RELISHING THE COLD seems almost a religion. I got into my car at Bon Soo to coax the blood back into my fingers just as Gerald Desmoulin and his two young daughters headed cross-country on skis. "We're only going three miles," he explained. "It will warm us up. If you let weather stop you up here, you'll spend more than half your life indoors."

Skiing may have come to North America via Lake Superior. "We can't prove it," said Ray Leverton, curator of the National Ski Hall of Fame at Ishpeming, Michigan. "But so many Scandinavians came here to fish and work in the mines, it's as good a candidate as any."

The bread-loaf mountains around the lake aren't as high as the Rockies or Sierra, but neither are the prices for skiing them. Inadequate snow is seldom a problem. Fifteen inches fell the day I skied one of the dozens of resorts around the lake. I found control difficult on slope angles hidden by the whiteout of falling flakes. Then I met Dick Nooe of Neenah, Wisconsin, who wears a banner that reads, front and back, "blind skier."

"I like figuring out the fall line of the slope by the way it feels," said Nooe, who lost his sight in Korean War combat. To steer him away from trees and other obstacles, family members follow, shouting "left," or "right sharp" when necessary.

"I accidentally directed him into a pile of

Creatures four-legged and two play along Michigan's Au Train River, one of hundreds of streams emptying into Superior's clear depths. Sand and warm water draw swimmers eager to use all of the brief summer. The frigid lake itself draws only the brave and the crazed.

boulders once, and he banged his knee," daughter Marikathryn said. "My brother ran him into a wire fence. We felt terrible, but he just gets up and keeps going."

We talked while warming up in the ski lodge, recovering from slope-side temperatures that threatened to freeze my sunglasses to my forehead. A question nagged at me: How did the Native Americans keep warm in winter without central heat and high-tech fiber-filled clothing?

Halfway between Thunder Bay and Duluth and 35 miles west of Lake Superior, I met a man the following summer who knew the realities of primitive life. Canoeing across Gunflint Lake, I eased ashore at the cabin of Charlie Cook, born to a Cree woman and a Scottish trader some 80 years ago. We talked on his front step as Charlie tossed ground corn to a mallard hen and her brood that waddled up the shore for an expected handout.

"My mother make socks and mittens of rabbit fur," he said in his shortcut English. "Never get cold. Make blanket this thick," he said, spreading his hands six inches. "Away

Light as the wind, nimble as a fish, a kayaker glides past sandstone bluffs on the Wisconsin coast in Apostle Islands National Lakeshore. These sheltered waters hold memories of Ojibwa filing by in birchbark canoes and of French-Canadian voyageurs straining at loads of beaver pelts. The Ojibwa knew Superior as Kitchi Gami, or "great lake."

from home, you can roll up in blanket, sleep in 40° below."

Although familiar with Indian wear, Charlie laughingly disclaimed his forebears' customs. Did he make ceremony after shooting a moose, to thank it for the gift of sustenance? "No, no, no," he said pleasantly. "My grandfather did, not me."

Back across the lake, Bruce Kerfoot smiled and shook his head. "It's ingrained in him to deny Indian ways, because the early white men insisted they were bad," said the owner of the Gunflint Lodge, a fishing resort run by his family for more than 60 years. "I've shot moose with Charlie and caught him putting part of the liver in a tree. He claimed he was just caching it, but it was an offering."

"The Indians looked after me in a very unobtrusive way when I first came here to run a fishing camp," said Bruce's mother, Justine, one of the lake country's living pioneers. "When they could no longer make a living in the woods, they went to the cities, where they were cheated and learned to cheat. But when Bruce was growing up, they were always around if he needed help in the woods."

At tribal headquarters in Sault Ste. Marie, Allard Teeple, a young Indian spiritual leader, sees economic opportunity in Indian-run gambling casinos for the Ojibwa living around Lake Superior. "We opened our first one in 1984," he said, "and it has created jobs and tribal income. The ability to earn money is the thing that people respect now."

But gaming has its critics even among Indians. Far from the clank of coins and the chiming slot machines, another tribal member says he believes his people should try to market their natural skills. "Indians look at the world differently from non-Indians," he said, hailing like an old friend a cormorant arrowing by. "We believe everything has a soul—trees, birds, the lake itself. More and more whites come to us saying they don't understand the

In a flurry of tulle and satin, snowflakes come alive in a dream scene from Tchaikovsky's The Nutcracker, *performed by the Duluth Ballet. Backstage, two extras fall into reveries of their own while awaiting the curtain call. The company, with eight professional dancers, elevates the city's reputation as a cultural beacon on the north shore. It was the choreography of cargo ships, entering and leaving the harbor that put Duluth on the map, however. Largest port on the Great Lakes, Duluth-Superior has shipped ore from the iron ranges for a century.*

world, that they want to know how to live again. That's what we really have to offer, knowledge of the natural world, not casinos."

Achieving harmony with nature is a lesson passed down the generations, I gathered from Joe Dan Rose, a biologist for the Bad River Ojibwa band at Odanah, Wisconsin. "The elders stress the importance of maintaining balance in your life and looking to nature as a model. A lot of us have lost sight of that. If you lose balance, bad things may happen."

BALANCE IS on many minds around the lake these days. Development may be spotty compared with that in milder regions, but the effects are showing up.

"Examples of every kind of environmental problem can be found here—sewage, industrial effluents, agricultural runoff, airborne pollutants," said Jake Vander Wal, a biologist with the Canadian government's environmental agency, Environment Canada. "There just haven't been enough of us to really wreck the place."

The early fur trade brought little change to the area's appearance. Lumbermen, however, virtually scythed the big white pines of Minnesota, Wisconsin, and Michigan. From the late 19th century into the early 20th, the 120-foot trees went into houses for an expanding nation. On the Canadian side, spruce was also used for paper-making pulp. Today's forests are stands of 70-foot aspen, birch, spruce, and pine, reaching for sun and superiority out of a confusion of undergrowth.

On the south shore the effect of that turn-of-the-century cutting was more profound than anyone dreamed. Vast areas were cleared, littered with slash, scarred by fire and erosion. Few white pines were left for regeneration. Much of the regrowth consists of trees used for

With a parting glance at her all-male crew in blue, Lt. Sandra Stosz formally ends her two-year duty as captain of the U. S. Coast Guard cutter Katmai Bay. "When your life is in danger during a storm," says Stosz, "it doesn't matter if your captain is a man or a woman."

pulp, not lumber, but reforestation continues.

Boom and bust has marked the extraction of other rich resources. Mining companies began following copper deep underground in the 1840s. The red metal drew miners from Cornwall, Germany, and Ireland across the sea and into the Keweenaw, the wolf's open mouth. Company towns sprang up. Football hero George (Win one for the Gipper) Gipp was born in a place called Laurium. Copper made fortunes for investors back East, and when Horace Greeley said, "Go West, young man," he meant more than California.

They shaved the Keweenaw nearly bald for houses, fuel, and timbers to shore up the ant-like mining tunnels. Still: "For a decade accidents killed a miner a week," said Michigan Tech professor Larry Lankton.

"My father and I both worked in the Quincy Mine," said 81-year-old Wesley Myllyla, still carrying the accent of Finnish parents. "One day he yanked a slab loose, and 25 ton of rock came down on him."

"Less than a century after it started, lower prices, big western mines, and the poor

economics of ever deeper shafts deflated Copper Country," said local historian David Halkola. "The population is not even half what it was, and older people are coming in to buy retirement homes."

Iron mining also began at mid-19th century but has endured longer. The early high-grade ore of Michigan's Upper Peninsula eventually was overshadowed by the greater supplies in the Mesabi Range to the west. Around the big lake the lower grade ore, called taconite, is now refined and concentrated into pellets for shipment to the steel mills down the lakes. Many of those mills have closed in the face of recycling and less costly steel imports.

"Mining really settled much of the Upper Peninsula," said Don Ryan, spokesman for Cleveland Cliffs, which manages the two remaining iron mines in the area. "The two that are left employ 2,200 and pump 250 million dollars a year into the economy. But with the recession and less use of steel, only 12 mines are operating in all North America, compared with 22 in 1980."

DIMINISHED AS WELL is the fleet of big ships that carry ore through the locks at Sault Ste. Marie to the lower lakes and then to midwestern steel mills. The loss of one ship added a horrifying chapter to the legends of Superior. During a November storm in 1975 the ore carrier *Edmund Fitzgerald* apparently dove like a 730-foot porpoise beneath the waves before any of her crew of 29 could grab a life jacket, too fast even for a distress call. She was found in two pieces at 530 feet. No bodies were recovered.

One man's act of kindness haunts him still. Two nights before the tragedy, Jack Mahoney was tending bar in Marquette and helped two young sailors find a ride to Duluth. "They told me they'd lose their jobs if they didn't get there by morning," he told me. "So I found a guy who gave them a ride, and they got there in time to ship out . . . on the *Edmund Fitz*."

The newest lakers of a thousand feet in length are captives of the lakes, too large for the Welland Canal around Niagara Falls, which leads to the Atlantic. "For exports, whether we like to admit it or not, we are mostly a transshipper—sending things on to St. Lawrence River ports so they can go to the rest of the world from there," said Davis Helberg, director of the port authority at Duluth.

"We're still the 17th biggest port in the U. S., despite being iced-in three months a year. We ship more than 40 million tons of materials annually; half of that is iron ore. Next is low-sulfur coal from the West. And we ship almost five million tons of grain, much of it going overseas. But the heyday is over."

Grain is the leading export out of Canada's Thunder Bay, but sales were cut in half by the collapse of the Soviet Union. Subsidized railroads, providing year-round transportation, have also cut into the port's share of exports from western Canada.

The most recent bonanza around Superior

Pushing the spring, the Canadian Coast Guard cracks open a shipping lane into Thunder Bay. "It's brute force—steel against ice," says Capt. René Turenne of the 230-foot Samuel Risley ripping through ice two feet thick. With a slowdown in the steel industry and growing use of West Coast ports, fewer ships are following in its wake.

Planting season in the Midwest means potash-moving time on the lake. A deckhand sweeps the last of 18,000 tons of Saskatchewan potash—an ingredient of fertilizer—into a ship's maw at Thunder Bay. It would require a train 180 cars long to move the same amount. In Wisconsin waters Marty Erickson untangles a whitefish from a gill net winched up from 150 feet deep. The fish will likely end up on a dinner table in Chicago. The fourth generation of his family to fish commercially, Marty has a strategy: "Work hard and watch the weather."

has gone largely unheralded outside Ontario. East of Marathon three mines are yielding almost a ton of gold a week—a quarter of Canada's production.

Volcanism at Superior almost three billion years ago brought gold in solution that squeezed into porous earlier rock and dispersed, instead of solidifying in a vein. Suffused in vast expanses of underground rock, it must be removed by giant machines and separated chemically, no job for a sourdough with a sluice.

"These are among the newest and safest mines in Canada," said Don Hriskevich as an elevator sped us a half mile down at the Williams Mine, largest producer of the three.

A gale of pumped-in fresh air blew against us as we splashed through puddles of water in caverns as big as a subway station. Safety rooms with fireproof doors and auxiliary air supplies were scattered throughout the mine's ten levels. For the dangerous job of loading rock loosened by explosives, tractors are at risk, not people. A front-end loader growled into the branch off our tunnel, and the driver dismounted. Using a remote-control console, he directed the machine into a roomful of blasted ore; like an obedient beast, it loaded a hauler the size of a small swimming pool.

Some 350 million (U. S.) dollars' worth of gold flows annually out of the mines, which employ about 1,200 workers at an average salary of $50,000. Most live in Marathon, still heavily dependent on a pulp mill. The town receives a million dollars a year in taxes from the mines, and federal and provincial governments get millions more. Geologists say the bonanza may last another 20 years.

Living around most of the lake requires mining for currency wherever you can find it, frequently from the pockets of tourists. Completion of a circle-route highway in the 1960s made it possible to drive completely around Superior, often within sight of it. Along the

way whole communities work at persuading passersby to pause.

WHITE RIVER, a little town on the highway 50 miles east of the lake, long advertised itself as the coldest spot in Canada, a dubious draw. A 30-foot painted thermometer visible from Highway 17 claimed that in 1935 the temperature plummeted to 72° below zero.

Nowadays the town boasts about a famous bear cub. Six years ago a local historian found that in 1914 a troop train stopped in White River and Capt. Harry Colbourn bought a black bear cub as a mascot. The cub—named Winnie for the soldier's home in Winnipeg—sailed to England and was turned over to London Zoo when the troops went into combat.

Tame as a dog, Winnie became a favorite of British children, among them a boy named Christopher Robin, son of the author A. A. Milne. Milne's books about his son and a toy bear—Winnie-the-Pooh—and Pooh's animal friends became children's classics. It all started in White River, the town would like you to know. In 1992 a bear statue eclipsed the thermometer.

Bayfield, Wisconsin, changed from fishing town to sailing mecca in a couple of decades. In 1970 the Apostle Islands just offshore were designated a national lakeshore, guaranteeing uncluttered vistas for yachtsmen. Skipper Neil Raymond let me take the wheel of the 30-foot *Catchun-Sun* while he chatted about sailing on Superior.

"This lake creates its own weather," he said, as a stiff breeze sent us surging through a light chop in brilliant sunshine. "I've been in storms offshore that were never reported on the marine radio. But you can always duck behind these islands for safety."

"Hey, it's just a blizzard," say folks in Thunder Bay as children race to St. Peter School. Despite appearances, weather closes schools here only an average of one day a year. Demographics is another matter: St. Peter shut its doors last summer because of low enrollment.

At the foot of the hillside town and in two nearby communities, pleasure boats nose into some 500 slips. Boaters eat well, so fine restaurants sprang up ashore. One of them fulfilled a dream for a couple of music teachers, Mary and Jerry Phillips.

"We bought this house as a summer place in 1973, then began renting rooms," said Jerry Phillips, from an antique chair in the stately Old Rittenhouse Inn. "We started serving breakfast, then dinner.

"We try to present a regional menu," he said, "and people bring us things unexpectedly. A man just came in with some chanterelles, those lovely golden mushrooms. They'll be on tonight's menu. A guy came in one spring day and said, 'The fiddlehead ferns are out,' and we said, 'The what?' We featured them for days."

On the Minnesota shore a successful artist told me, "Young people complain that they can't find jobs. I tell them if they want to live here, they've got to create their own."

Within the lake itself, a renewable wealth was nearly exhausted. The lining of mostly

volcanic rock leaves Superior free of sediment and infertile compared with the other Great Lakes, exactly the kind of habitat preferred by lake trout. Feeding on smaller fish such as herring, they grow slowly to lunkers of 20 to 40 pounds, prized by sportfishermen. A tastier native, the whitefish, is a bottom feeder more often netted than hooked.

Rail lines built in Wisconsin and Minnesota in the late 1800s expanded commercial markets for both fish. Fishermen from Norway joined the ethnic mix around Lake Superior—descendants of French explorers, Finnish lumbermen, and Cornish and German miners as well as Swedes, Danes, and Scots. Among the Norwegians was the grandfather of Grand Marais artist Howard Sivertson.

"Here he found a chance to fish and own land in a familiar climate," Howard told me. "The shoreline even looked like Norway's, without the mountains in the background."

HUNDREDS OF FISHERMEN once set their gill nets in Superior. By the 1950s the sea lamprey, moving up from the lower lakes, began decimating the lake trout, a major commercial species along with whitefish and herring. By the 1960s commercial trout fishing was severely restricted. Meanwhile overfishing prompted the crash of herring numbers. "A lot of us were suddenly looking for a new way to make a living," said former fisherman Julian Nelson at Bayfield.

The two species have been recovering, and some remaining fishing operations are prospering. A chemical with a tongue-twisting name—3-trifluoromethyl-4-nitrophenol—released in lamprey spawning streams has been suppressing their populations. Antipollution enforcement has greatly reduced smothering siltation from mining and forestry operations.

"We've got to take care of the lake or there won't be fish for anybody," said 45-year-old Dean Halvorson, as we balanced aboard his wallowing workboat near the Apostle Islands. "We can live with regulations."

In the narrow wheelhouse his wife, Maurine, steered to one of their three trap nets, with mesh wings that guide trout and whitefish into a one-way chamber. "You don't waste fish in a trap net, because they're still alive when you get here," he said, dipping the squirming catch onto his boat. Maurine tossed an undersized whitefish back to freedom. "A lot of fish die and spoil in gill nets."

As a deckhand took the controls for the trip back to shore, the Halvorsons gutted their catch and iced it down for delivery to retailers and local restaurants. They average 3,000 to 5,000 pounds a week over a five-month season. "This is a great way to make a living," crowed Dean, as wind ruffled his blond curls. "Out here on the lake in the fresh air."

"You won't be saying that when the fall storms come," muttered Maurine.

Squalls of a different sort have arisen over the lake's future. "Its fresh water is our last major untapped resource," said Todd Kessler

Cabin fever afflicts four-year-old Lacey Day, who on a cold morning in Sault Ste. Marie, Ontario, feels as chained up as her dog, Bear. In fair weather her parents take her to watch ships thread the locks on the St. Marys River between Lakes Superior and Huron. Once carrying more cargo annually than the Panama or Suez Canals, the "Soo" locks now rank third.

of the Inland Sea Society, a citizens group based in Bayfield. "We shouldn't screw up that one."

Damaging pollution of the other Great Lakes has bred concern for Superior. An International Joint Commission (IJC), with representatives of both the United States and Canada, has pronounced the lake "relatively pristine." The commission also recommended in 1990 that Superior become a "demonstration" lake for environmental protection. Both governments, said an IJC report, should create programs aimed at "zero discharge" of pollutants into its waters. The governments have agreed initially to target nine toxic substances, including DDT and PCBs (polychlorinated biphenyls), both of which may arrive airborne from thousands of miles away.

Can Lake Superior become a model of purity, a wilderness home to hundreds of thousands, but stay unspoiled by modern living?

"Zero discharge is a noble intent, but it is a major concern to those of us in commerce," said Davis Helberg, port authority director in Duluth. "I would hate to see drastic action hurt business and then find out later that it wasn't necessary."

"We welcome development," said Mary Burnett, who operates the Serendipity Gardens Café in little Rossport on the Canadian shore, "but we want it to proceed at our pace. And we want it done right."

ROSSPORT came to symbolize for me the enduring charm of the lake country. A couple dozen houses lie scattered against a slope overlooking a sky-blue bay and emerald islands. The only hotel is a restored 110-year-old railroad guesthouse known as the Rossport Inn—six rooms with bathrooms down the hall. From the wooden balcony you can watch a sailboat, maybe a couple of launches from Duluth or Thunder Bay cruise in and tie up. Their crews stroll up the hill for a dinner of fresh lake trout. Uncertain weather keeps the village small.

Something in the seesaw of temperatures seems to breed vigor, for the lakeshore is awash in ageless oldsters. "Everyone stays active," explained Don Jenicek of Washburn, Wisconsin, whose 83-year-old father had just taken on a house-painting job. "You just walk out the door and there's something to do."

I sailed out of Rossport one August morning on a fishing boat captained by 84-year-old Ray Kenney, retired school principal and lifelong fisherman. First and only "mate" was his wife, Josie, in her early 80s. The other passenger was 96-year-old George Paradise, a retired Iowa judge who has been coming to Rossport every summer for almost half a century.

"My doctor tells me I improve when I come here—lower blood pressure," said the judge, a small man, sunbrowned despite the pith helmet that covered him like a parasol.

"He and Josie won't admit it, but they're very competitive," Ray whispered as we trolled over shoals 50 feet below. Josie struck

Converts to Superior's rugged graces, Brother Peter, left, and Brother Steven, of the Society of St. John, exercise body and soul on Michigan's Keweenaw Peninsula, site of their new monastery. Says Peter, "At first the only thing we had was the view, and that was nearly enough."

first with a seven-pound lake trout. The judge answered with eight and a half. I reeled in a six-pounder. In less than an hour we had more than 20 pounds of trout in the icebox.

Superior showed muscle on the trip home, kicking up five-foot waves that broke over our bow. The judge sat silently in the stern with an impassive Josie. I chatted with Ray only to hide my own uneasiness. We finally chugged behind the islands near Rossport, the waters grew still, and the judge wandered forward, brimming with optimism.

"Over there is Eagle Rock," he said, pointing to a slab of old lava. "I was fishing here one Sunday with an Episcopal priest. He insisted that we have a little church service there, and then he told me to lead it." Proudly he recited his words from that day:

"Look around you at the hills and trees and the immense quantity of fresh water. Now look overhead at the canopy stretching over everything, a dome without pillars. Nature is the foundation of all religion. And this is as fine a church as any man ever preached under."

Amen, Judge Paradise. □

S T.

CAPITAL OF

MONUMENT to one man's obsession, Peter the Great's city graces the cold banks of the Neva River. From the Winter Palace, adorned with mythological figures, a succession of tsars and tsarinas ruled Russia for more than 200 years, until Lenin, the "red tsar," moved the capital back to Moscow in 1918.

Article and photographs by
STEVE RAYMER
NATIONAL GEOGRAPHIC STAFF

PETERSBURG

THE TSARS

FRESH FROM A BALTIC STORM, snow brightens the neoclassic columns of the Kazan Cathedral, completed in 1811 by Alexander I, one of St. Petersburg's most ambitious builders.

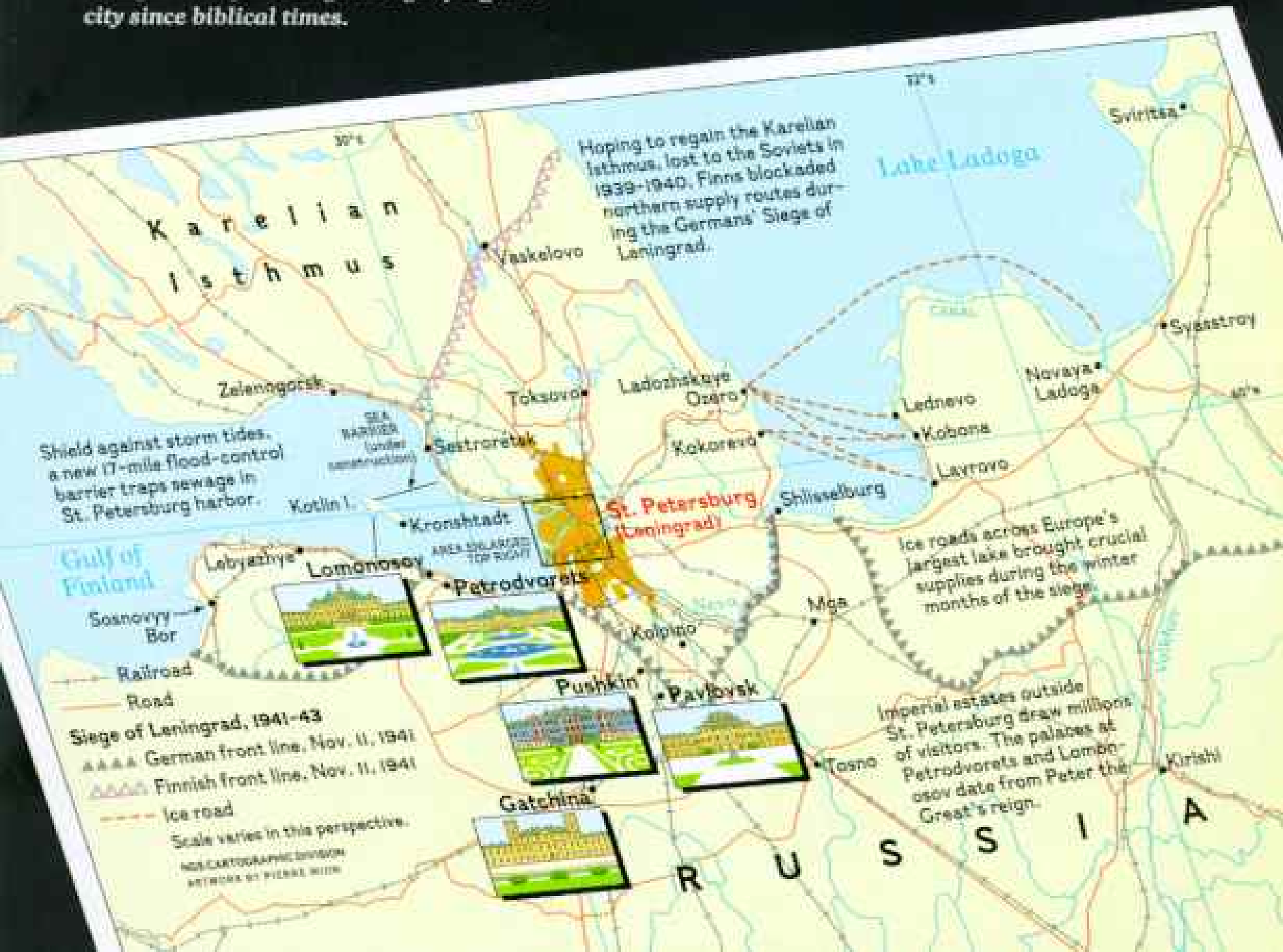
A MORE FANCIFUL SIDE of Russian architecture, little seen in St. Petersburg, is reflected in lavish mosaics gracing the Church of the Resurrection, built where Alexander II was assassinated in 1881.

ST. PETERSBURG—THE HEROIC CITY

"The haughty Swede here we'll curb and hold at bay. And here, to gall him, found a city." Thus, according to the Russian poet Pushkin, did Peter the Great in 1703 found his city on the Baltic Sea, then virtually a Swedish lake. Peter's stronghold, named for his patron saint, later suffered the agonies of war on an unsurpassed scale. Blockaded by German troops in the fall of 1941, the city—then called Leningrad—saw its supply lines cut off with only a month's food in reserve. Nearly a million died, most in the "winter of starvation," 1941-42, when rations were reduced to one-sixth or less of normal. Miraculously some 1.5 million survived. Supply routes across frozen Lake Ladoga eventually enabled the Leningraders to outlast the infamous "900 days," living to tell of the longest siege of a great city since biblical times.

POINTS OF INTEREST

1. Admiralty
2. Alexander Nevsky Monastery
3. Beloselsky-Belozersky Palace
4. Cathedral of the Transfiguration
5. Church of the Resurrection
6. General Staff Building
7. Kazan Cathedral
8. Mariinsky Theater
9. Peter and Paul Fortress
10. Smolny Institute
11. St. Isaac's Cathedral
12. Summer Garden
13. Winter Palace/Hermitage
14. Yusupov Palace



Where he first set foot on the Baltic coast, legend has it, Peter the Great proclaimed: "Here there shall be a town." And so on Hare Island (right) on May 16, 1703, workers laid the foundation for the Peter and Paul Fortress, his bastion against the Swedes. The city of St. Petersburg soon spread across the Neva delta. It replaced Moscow as Russia's capital in 1712.

A traveler in his youth, Russia's great westernizer was determined that his new capital imitate the imposing seaports of London and Amsterdam, which were familiar to him from his brief stints as a shipwright. Only an autocrat and visionary could have built such a city, and neither Sweden nor a reluctant court in Moscow could stand in his way as he dragged Russia, a backward giant, into the modern world. At prodigious cost to the imperial treasury, a city more European than Russian thus rose from the Baltic swamps.

Today Peter's legacy is everywhere: in the wealth of baroque and neoclassic architecture; in the dozens of research centers famous for discoveries in chemistry, genetics, psychology, and space sciences; and in the shipyards that once equipped the Soviet Navy for nuclear confrontation with the West. Accessible year-round, the harbor links "Peter," as its five million inhabitants call the city, to the open sea.

During World War I, Tsar Nicholas II Russified the city's name, changing it to Petrograd, or City of Peter. But a name change could not mask the bankruptcy of the Romanov dynasty, which was toppled by revolution in 1917. In 1924, following the death of Lenin, the Soviets—who had returned the government to Moscow—changed the name again, to honor the Bolshevik leader. The name Leningrad lasted until 1991, when the new Russian Parliament quietly approved the city's petition to resume its historic name.

ORNATE FACADE and opulent interiors mark 150-year-old Beloselsky-Belozersky Palace, which long served as a headquarters for the local Communist Party and thus survived the Soviet era intact.

A party worthy of Catherine the Great herself, the grand ball at Yusupov Palace was one of several such fetes in St. Petersburg last New Year's Eve. Playing period parts, actors conjured up the Romanov era for an audience of wealthy foreigners by parading to a polonaise in meticulously researched costumes. The highlight of an expensive package tour, this ultimate St. Petersburg experience included Caspian Sea caviar, French wines, and Russian blini served in a room gleaming with crystal and gold.

Between courses guests could visit the salon where, in 1916, Prince Felix Yusupov attempted to kill the fanatic monk Rasputin. Resentment of his influence over Nicholas II, last of the Romanov dynasty, and his empress, Alexandra, helped fire the revolution that led to their arrest and execution. Refusing to die even after being poisoned and shot, Rasputin chased the horrified prince outside, where co-conspirators finally drowned the monk in the frigid Moyka Canal.

Elsewhere in St. Petersburg,

today's Russian aristocracy of entrepreneurs and artists rich in hard currency celebrated their new prosperity with extravagant parties. At these galas the air was perfumed with nostalgia for a Russia long gone—an age of glittering accomplishment when St. Petersburg reigned as a world center of music, ballet, and literature. Here flourished such writers as Pushkin, Gogol, and Dostoyevsky and the composers Tchaikovsky, Rimsky-Korsakov, and Mussorgsky.

Reflecting that legacy, the city counts some 30 theaters devoted to the performing arts. Renowned the world over among balletomanes is the legendary Mariinsky Theater (above), known during the Soviet era as the Kirov and still the hottest ticket in town.

Tsar Peter and, later, Catherine the Great filled St. Petersburg with mentors from abroad, hoping to foster the artistic and liberal values of the European Enlightenment in rough-hewn Russia. The aristocracy, who spoke French and married their children to French and English nobles, did their best to imitate western Europe in everything from architecture to manners.

Under communist rule, the arts—though conservatized by Soviet censors—were lavishly subsidized. The Bolsheviks may have made Moscow the political capital of the Soviet Union, but St. Petersburg remained its cultural rival—a position Petersburgers are resolved to maintain.

NAVY TOWN from the start, St. Petersburg through all its incarnations has relied on the sea for its livelihood. On the Neva River a full-dress submarine crew celebrates Navy Day 1992.

SCENE OF VICTORY PARADES and political uprisings, Palace Square fronts the government's General Staff Building and the Alexander Column—a monument to Russia's triumph over Napoleon in 1812.

Light from an autumn sun dances about the Great Hall (below) of Catherine Palace in the nearby town of Pushkin, formerly known as Tsarskoye Selo, or "tsar's village." Once the summer residence of Catherine the Great, the palace remains a peerless triumph of Russian decorative art. Reduced to a charred shell during the Siege of Leningrad, the estate and its elaborately domed chapel (right) have been stunningly re-created, thanks mainly to a massive postwar restoration effort by the Soviets.

Modern-day Michelangelos, two members of a four-man team painstakingly reproduce, in an antechamber to the ballroom, one of the palace's great ceiling paintings, "The Marriage of Bacchus and Ariadne." In the adjacent room is the newly re-created 9,000-square-foot "Triumph of Russia," the largest ceiling painting in all Europe. "I hope to God they are able to finish their work," says assistant director Nikolai Nagorsky, "because there isn't another generation of geniuses who know this craft."

"I HAVE A WHOLE LABYRINTH of rooms . . . and all of them are filled with luxuries," wrote Catherine the Great of the Winter Palace and the adjoining Hermitage, where Pavilion Hall fills one small corner.

ALIVE WITH CLASSICAL SCULPTURES, Peter the Great's Summer Garden gleams under an autumn snow. By special decree, Nicholas I restricted use of the park to officers and the "decently dressed."

Storming heaven, the tsars filled St. Isaac's Cathedral (left) with icons, frescoes, gold, marble, and tons of malachite from the Ural Mountains. One of the world's largest domed cathedrals, it cost ten times as much to build as the Winter Palace.

Flushed with victory over Napoleon, Alexander I—who was intent on making St. Petersburg the most exalted capital in Europe—studied 24 different plans before the cathedral's foundation was laid in 1818. Designed by a French draftsman, Auguste Montferrand, the massive building rests on 10,000 tree trunks sunk by an army of serfs into the marshy banks of the Neva. The gilded dome, covered with more than 200 pounds of gold, has become a city landmark, visible from 25 miles away.

Peter the Great had brought the church under state control in 1721, two centuries before the Bolsheviks cast religion into near oblivion. After the 1917 revolution both the clergy and a stubborn flock of believers were treated with scorn and subjected to arrest and harassment. Like most of Russia's great cathedrals, St. Isaac's survived the long night of communism as a museum.

Officially St. Isaac's remains a museum, with worship services only on major holy days. But there is no lack of churches for the faithful—or for the curious, many of whom fumble to cross themselves, mystified by rituals long forgotten. At the Cathedral of the Transfiguration (above) group wedding ceremonies help satisfy a new longing among young Russians for spiritual identity.

Steve Raymer's book *St. Petersburg* will be released next fall by Turner Publishing, Inc., Atlanta, Georgia.

HALLOWED HALLS of Russian academia fill Vasilyevskiy Island, where institutes, libraries, and museums along University Embankment embody Peter's dream of pulling Russia into the modern world. □

Passion Vine Butterflies

A Taste for Poison

Article and photographs by
DARLYNE A. MURAWSKI

Balancing on a passion vine, a female Heliconius *butterfly lays a raft of about 30 eggs. Natural cyanide protects the plant from most leaf-eating caterpillars, but all* Heliconius *species are immune to the poison. Adults even synthesize cyanide, making themselves distasteful to birds. Born survivors, the tropical insects can live 25 times longer than most other butterflies.*

A PAIR OF LONG BLACK WINGS with stripes of brilliant yellow flap easily in the cool dawn, propelling a slender body in stately fashion through the rain forest understory. As if lighter than air, the butterfly wafts past me directly toward a flower whose orange petals are unfolding with the day. She is a no-nonsense flier, given not to crazy zigs and zags but to the unwavering pursuit of a straight course.

Entranced, I watch her land, anchoring herself to a petal with four wiry legs. Immediately she uncoils her shiny black proboscis, drives it into the tube of the flower, and begins thrusting her head up and down repeatedly. Within ten minutes she has mined a ball of white pollen larger than her head. By coiling and uncoiling the spring-like proboscis, she works the pollen upward to a point where she can feed on it throughout the day. I notice that her wings are terribly tattered.

Suddenly a black-and-orange butterfly, no less threadbare, swoops in. "Black and yellow" opens her wings to shield the flower. She plunges her proboscis down the tube for an instant and sucks up traces of nectar. The interloper pounces feet first on the defender, again and again, battering her delicate wing scales. Thwarted, the famished butterfly at last loops away in search of an easier meal.

Food fight erupts over a Psiguria *flower (opposite) as two* Heliconius *battle for access to its nectar and protein-rich pollen. Many butterflies feed on nectar and must amass a lifetime supply of protein while eating leaves in the caterpillar stage. The process can take months, during which they are vulnerable to predators.* Heliconius *zips through the caterpillar stage in two weeks because it is able to feast on pollen protein as an adult.*

Heliconius species span the Americas (map) but are most plentiful in rain forests like those of Colombia, where researcher Mauricio Linares (below), has focused his studies.

To test the victor further, I gently grasp the veins on the leading edges of the forewings and pull. She hangs on. I pull harder. And harder. Still she does not loosen her grip.

TENACIOUS IS NOT A WORD that springs to mind for a butterfly, yet it aptly describes the 38 species of long-winged butterflies in the genus *Heliconius*. In fact, these spectacular butterflies are full of surprises. I got to know them in Costa Rica, in the sweet-smelling forests of Corcovado National Park, where I soon discovered that there is even more to them than an iron will and a glorious set of wings.

I had come to investigate their habits as pollen feeders—a trait that makes them more like bees than butterflies—and plant pollinators. Discovering that they also compete for flowers by aggressive kicking was an unexpected bonus. In unusually dry times, when food is scarce, they literally fight for their lives.

Most adult butterflies live about ten days, but *Heliconius* can live for several months. (The record is nine months.) *Heliconius* butterflies have evolved relatively large brains and sharp memories. And all of them are poisonous. Their brilliant markings remind predators of that so effectively that other butterflies imitate them.

Heliconius butterflies are adaptable too. When their surroundings change, they are able to acquire a whole new set of markings to ensure their survival. Despite their adaptability, they remain dependent upon a fragile web of interacting organisms, including host plants and sources of pollen and nectar. This, of course, makes them vulnerable to destruction of habitat, a serious threat to many of the world's 17,000 butterfly species.

Corcovado National Park, 141,000 acres of richly varied habitats, is the stuff of dreams for lepidopterists. It harbors ten species of *Heliconius*, in the subfamily Heliconiinae, often called longwings. Their other popular name, passion vine butterflies, derives not from the orange-blossomed plants adults pollinate but

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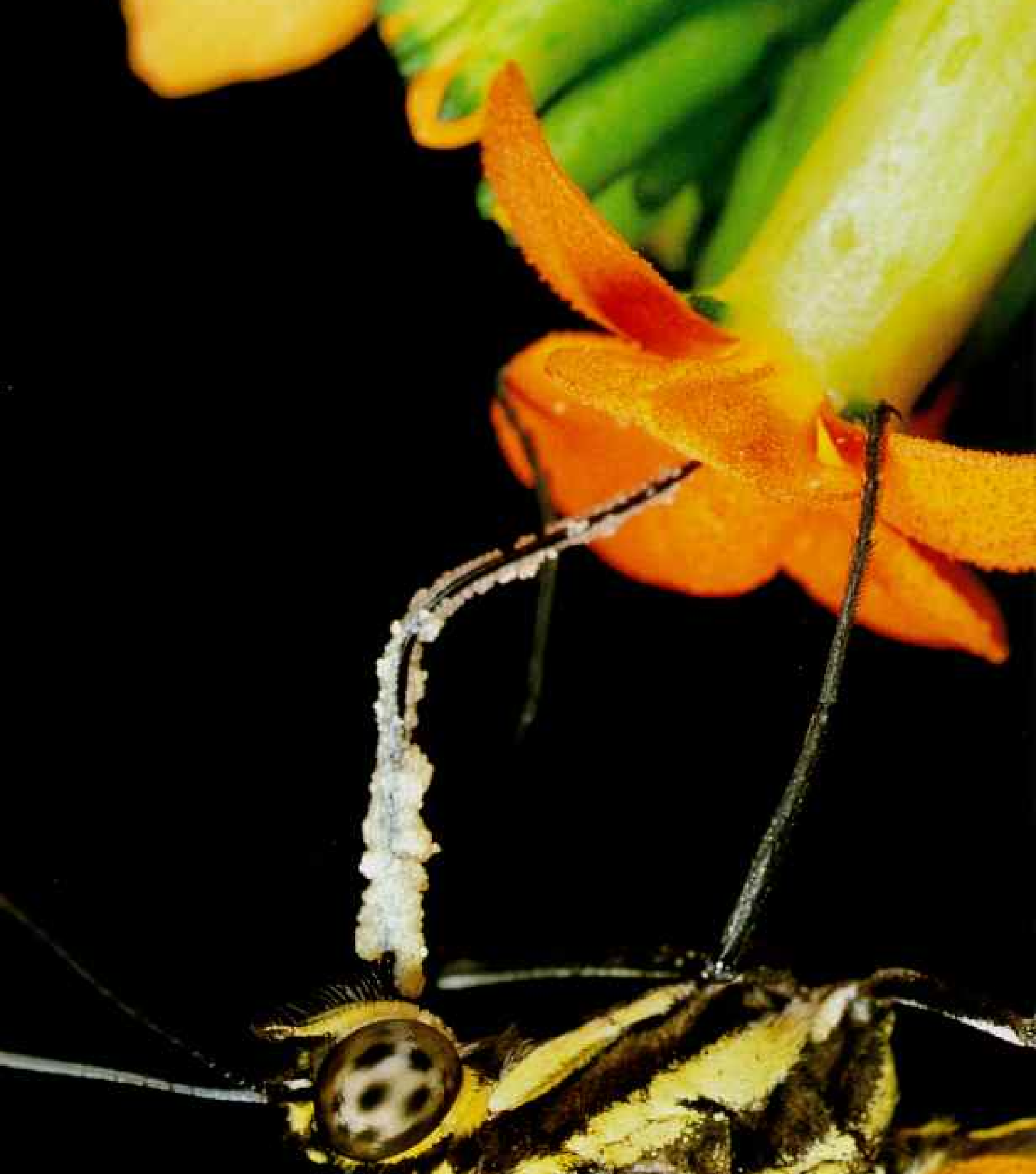
DARLYNE MURAWSKI, a research associate at Harvard University, is currently working on the ecology and genetics of tropical rain forest trees. Before turning to science, she earned a master's in fine arts and now bridges the two worlds with nature photography. This is her first article for NATIONAL GEOGRAPHIC.



from the vines the young caterpillars gobble in preparation for their ten-day metamorphosis, inside the chrysalis, into winged maturity. Some 500 species of passion vines native to Middle and South America and the southern United States host heliconiine caterpillars.

My fascination with *Heliconius* and the forests they inhabit began in childhood, when I would lose myself in the accounts of 19th-century explorer-naturalists like Thomas Belt and Henry Walter Bates, who wrote of the butterfly's "elegant shape, showy colours, and slow, sailing mode of flight."

My chance to witness this painted flight came in 1979, when, as a doctoral student at the University of Texas at Austin, I joined the first summer course in Corcovado taught by Larry Gilbert, now chairman of the zoology department. Several of us collaborated with him, catching and marking longwings for a study of their populations.

"A hot spot for *Heliconius*" is how Larry describes the patchwork of young and old forest and open ground where we worked. "They like disturbed sites and forest edges, where they're more likely to find flowers and host plants." Even so, longwings are quite rare, averaging only six to nine per acre for all species in Corcovado.

Pollen from a Psiguria *flower clings to an inch-long proboscis (opposite), which* Heliconius *uses to scrape the flower's anther (above). The author holds a live specimen in her lips as she collects its pollen load. "I don't have three hands," she explains.*

EQUIPPED with a long-handled butterfly net, at first I would rush in for the scoop. Scaring up a *Heliconius*, I overcompensated by swinging the net wildly—and was left watching in dismay as the butterfly escaped. Over the course of time, though, I learned where to wait, how to stalk them, and when to scoop.

Another problem was telling the species apart and weeding out various identical-looking but unrelated butterflies. And when I was sure I'd netted a *Heliconius*, I had to figure out its sex. Females display the same striking colors and patterns as males, but males have a thinner abdomen, with claspers on the end to grip the female while mating.

During mating, males deposit both sperm and a pungent chemical that diffuses into the air from the end of the female's abdomen. The odor, which varies among species, repels other suitors for a time. If you catch a whiff of something like witch hazel, it's probably the "anti-aphrodisiac" of a newly mated *H. erato*. I wish I could bottle *(Continued on page 132)*

MARK W. MOFFETT

The journey from egg to butterfly

Like a delicately balanced fluted vase, the egg of a *Heliconius cydno* rests on a passion vine tendril (above). *H. cydno*, like other *Heliconius* species with cannibalistic offspring, lays individual eggs in isolated spots, gluing them to the vines.

For three to five days the egg, smaller than a grain of rice, stands undisturbed; then a minuscule larva, or caterpillar, munches its way out with scissor-like mandibles. The larva's first—and only—order of business is to eat, and its appetizer is the egg from which

it emerged (far left below).

As the caterpillar grows, it sheds its skin, going through five distinct stages called instars. At the beginning of each stage the caterpillar resembles an expandable sack that fills up as it goes to work as an eating machine. Within two weeks the rapidly growing larva has shed its skin four times and reached an inch and a half in length (left below). For a few hours after each shedding, its spines, usually hard and black, are soft and translucent.

Now fully grown, the larva begins its transformation into a butterfly. It wanders to a secluded spot and spins a silk pad on the lower surface of a leaf or twig. It hangs upside down from this pad (below) for a day or two in the prepupa stage. Then the hardened skin splits near the head and the prepupa begins to writhe, sliding the skin toward its tail section like a stocking gathered around a foot (below center).

In a precarious move the prepupa "steps" out of the skin and finds a footing on its silk pad. Some fall off at this point, but most manage to cling to the pad, which holds like Velcro.

Now called a pupa, or chrysalis, the creature becomes still as its new skin dries and darkens (below right). Inside, a ten-day metamorphosis begins.

Hormonal changes trigger the breakdown of larval tissues and their reconstruction into adult ones. The dry shell separates from the developing butterfly like the loose outer layer of an onion.

Finally the shell splits open, and the fully developed butterfly emerges. Females are soon greeted by courting males; *H. cydno* males grasp females for back-to-back mating (above) and often fly off with them still attached. From this single union a female can store a lifetime of sperm, periodically fertilizing her eggs.

In a mating frenzy, a male connects with a female even before she has emerged from her chrysalis. A failed suitor flutters below. Researcher Erika Deinert—who inks identifying numbers and colors on males' wings—says half the Heliconius *species practice pupal mating; some males punch holes to get through.*

the sweet smell of a mated *H. hewitsoni*. I find it so appealing that I've acquired the habit of sniffing females of the species whenever I catch them. On occasion, walking through the woods, I've picked up the faint but familiar scent and followed it to a black-and-yellow *H. hewitsoni* hidden among nearby leaves.

"You are what you eat" goes the popular saying, and I can think of no better confirmation of it than *Heliconius*. Other butterflies subsist on a varied menu that features nectar—the sugary liquid that builds up each day in the tubes of flowers—rotting fruit, dung, and urea (from animal urine). Yet only *Heliconius* and one other member of the subfamily feed on pollen as well as nectar. For them nectar is an energy fix, imbibed in quick sips that supplement their daily meals of pollen.

In Corcovado certain plants, especially *Psiguria* and *Gurania*, have evolved ways to reward their *Heliconius* pollinators. The plants have mostly male flowers that are laden year-round with easily accessible pollen

within their orange or reddish petals (bright colors lure butterflies). Each flower lasts only a single day, so with every sunrise the butterflies enjoy the prospect of a fresh meal.

I never tire of watching the bobbing-head motion of a longwing harvesting pollen. Toothlike projections near the tip of the inch-long proboscis are thought to help fork up the large white grains clinging to the anthers of the flower. Female longwings collect more pollen than males, probably because of the demands of egg production. Most other butterflies lay a single batch of eggs before they die, but female longwings go on laying throughout their lives.

Food preparation involves regurgitating juice from the stomach onto the rolled pollen load and blending the ingredients by agitating the proboscis. Part of the haul escapes this treatment, so that when a butterfly moves from a male to a female flower, it usually deposits just enough viable pollen for the plant to set seeds. When the tacky grains are suitably liquefied, the butterfly turns on its head pump—there's actually a little pump in there—and draws the broth up the proboscis.

What goes in is a wholesome meal, full of protein and containing a far higher concentration of the ten amino acids needed for survival than other butterfly foods. The effect on life span is dramatic. A study of longwings raised in Larry Gilbert's rooftop greenhouses in Austin showed that those given a pollen-free diet died after about a month. But those fed on pollen lived six months, or even longer.

This is good news for anyone who breeds them in captivity. Ron Boender is one. Ron's enthusiasm for butterflies led him to early retirement from a career in engineering. In 1988 he opened Butterfly World in Coconut Creek, Florida. Now several other states have butterfly zoos, but Ron's place remains one of the largest exhibits of its kind. To the strains of Vivaldi's *Four Seasons*, hundreds of thousands of visitors alight every year to enjoy the spectacle of more than 2,000 butterflies.

LONG LIFE BRINGS EXPERIENCE—and knowledge. In *Heliconius* the learning center of the brain is proportionally larger than in other butterflies.

Back in the 1960s Larry found that individual butterflies make repeated stops at particular plants. He described this as "traplining," a behavior also characteristic of certain bees,

hummingbirds, and bats, all of which have a keen memory for their environment.

One morning I staked out a *Psiguria* plant and watched several longwings float in, one at a time, to check out the open flowers on each of the branches. The same ones later returned to the same flowers, often in the same order, throughout the day. It was as if they had drawn a detailed flower map, to which they referred as needed. When no longwing was looking, I plucked a flower. The butterflies that had already made stops at that flower looked stymied, fluttering up and down where the flower should have been. But they soon redrew their maps and then ignored that spot.

Next I taped a flower to a stalk without blossoms. Not one butterfly changed its flight plan to explore the "fake."

In the late afternoon, when nearly horizontal sunbeams cast a dim light on the forest floor, I occasionally spooked up a dazzling wing cloud from a resting-place in the shade. After a hard day of foraging, *Heliconius* go down with the sun, upside down, hanging by their feet in clusters of as many as a few dozen. Most come home to roost on precisely the same twig or tendril.

On occasion I accompanied fellow graduate student Jim Mallet on his inspections of sleeping butterflies. Jim knows more than anyone else about roosting longwings, but he can only suppose why they are homebodies. "The most likely reason," he told me, "is that it affords protection from predation by inexperienced birds, or possibly bats, that have not yet learned of the butterfly's distastefulness."

Distasteful? They are flying cyanide

Strategic defense tactics help passion vine plants fend off onslaughts of Heliconius caterpillars, some species of which stage coordinated assaults as they devour the leaves (opposite). Some plants sprout yellow protrusions (above) that closely resemble Heliconius eggs. These discourage females, which avoid laying eggs in occupied territory. Passion vines even enlist mercenaries for protection: Sugary leaf secretions (above, center) attract wasps and ants (top), which eat nearby eggs and caterpillars.

capsules! In Corcovado I saw how invulnerable they seemed; it was as if they lived in a glass bubble that no other animal dared break. Thomas Belt, who traveled in Brazil around 1870, had remarked on it too: "I observed a pair of birds that were bringing butterflies and dragon-flies to their young, and although *[Heliconius]* swarmed in the neighborhood, the birds never brought one to their nest."

Larry Gilbert thinks that it is amino acids derived from pollen that allow *Heliconius* adults to synthesize their own cyanide. They may even be primed with it during their caterpillar stage, a process Larry and his students are now looking into. Passion vines contain toxic cyanide compounds that repel leaf-feeding insects, but *Heliconius* caterpillars are somehow equipped to process these poisons.

My colleague Peng Chai was curious to determine what cues a predator to shun distasteful butterflies. At our research site in Corcovado he released butterflies of many species into cages containing jacamars. Did these resplendent cousins of the kingfisher show any innate preferences?

"No," Peng emphasized, "everything is learned. If they attack a butterfly, they generally consume it. At first naive birds attack just about anything, but they very, very quickly figure out what to avoid." Not surprisingly, they habitually avoided *Heliconius*.

Passion vine butterflies do give birds fair warning by their distinctive flying style. They fly slow and straight, using their long abdomen as a rudder. Such efficiency would be disastrous for tasty butterflies—ones like the blue morpho, a tropical giant that flits across forest clearings, or the ubiquitous skipper butterfly, darting about like a maniac. These are stunt fliers—typically short and squat of body, with a fast, strong wingbeat—designed to evade predators.

Fast fliers share another strategy: cryptic coloring on the underside of their wings. There's nothing muted about the wings of *Heliconius*. Blazing patterns—reds, oranges, yellows, and whites on a field of black—broadcast a warning: "Beware! I taste foul."

A hungry jacamar in Costa Rica prepares to thrash the wings off a nonpoisonous relative of Heliconius. *The bird avoids the cyanide-laced species. To distinguish between tasty and foul, the jacamar detects differences in color, body shape, and flight patterns.*

IF YOU'RE NOT TOXIC, your only insurance may be to pretend you are. And as the German naturalist Fritz Müeller discovered more than a century ago, even poisonous butterflies in the same area evolve the same color patterns. By their mimicry they reinforce a single, striking image that birds remember.

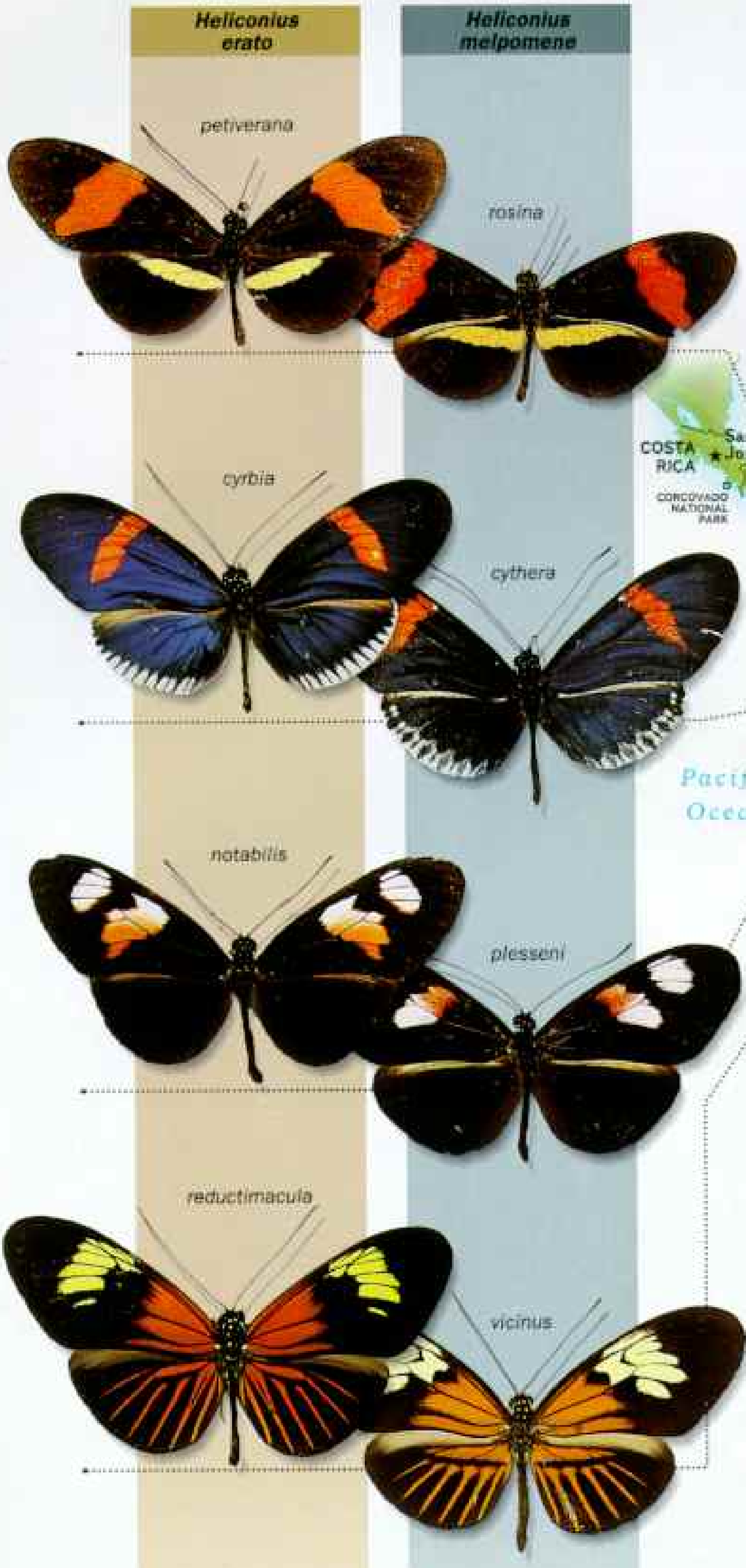
A place like Corcovado might hold a score of copycat species, some imitating unrelated butterflies or moths. To further confuse butterfly people, one *Heliconius* species may have as many as 20 distinct geographical races, each with different patterns mimicking those of other bad-tasting butterflies in their range.

Leaving Corcovado for the shrinking forests of the Colombian Andes, I visited my old friend Mauricio (Mauro) Linares, a biology professor at Pontificia Universidad Javeriana in Bogotá. Mauro has been exploring the genetic basis of mimicry. He has shown that *Heliconius* can adapt quickly to changes in habitat—but, in the face of rapid tree clearing, not always quickly enough.

One day we drove to within clambering distance of the Dagua pass, near Cali. Here, about 6,000 feet up, geography conspires to bring together three races of *Heliconius cydno:* one from the Pacific slopes to the west, one from the northern Cauca valley, and one from the southern part of the valley.

I was struck by the fact that the three races displayed an astonishing diversity of hybrid forms. To understand how the color patterns

The power of negative advertising



For butterflies there is safety in numbers—especially if they all don one uniform that warns birds to stay away. This uniform may differ from place to place, as revealed in the four pairs of Heliconius *at left. Each member of a pair represents a geographical race of its respective species. Although the "partners" are of two different species, they have evolved nearly identical wing patterns. Even unrelated butterflies and moths may join the masquerade. Once a bird has tasted a poisonous* Heliconius*, its color pattern is permanently filed under "Do Not Touch."*

Having a relative for dinner, a full-grown Heliconius caterpillar rears up to attack a smaller one on a passion vine. With half the species cannibalistic, Heliconius butterflies are among the few creatures that can stomach their cyanide-laced kin.

are passed down, Mauro has collected and crossbred generation after generation of *H. cydno* in captivity.

THAT'S HOW he got the surprise of his life. On March 25, 1988, Mauro walked into the university greenhouse and saw a ghost. The specter flapping before him was black, with the white and yellow markings of an entirely different species.

"The first thing that came to my mind," he recalls, "was, what the heck is *Elzunia* doing in here?" But it wasn't *Elzunia*. Through luck and intuition, Mauro had crossbred two *H. cydno* butterflies that had the right genes to produce a perfect mimic of the rare *Elzunia*.

Decades ago the region around the Dagua pass was home to *Elzunia*, a toxic butterfly restricted to forest, and its *H. cydno* mimic. As more and more land was cleared, *Elzunia* diminished in numbers, and the mimic disappeared altogether. "When I put the pieces together," Mauro said, "I realized I'd created a 'ghost of mimicry past.' "

Meanwhile a toxic longwing called *H. erato*, which prefers more open country, has proliferated, and with it a matching form of *H. cydno*. Mauro found that as few as five genes control the differences in wing patterns between the mimics of *Elzunia* and *H. erato*.

"This story," he says, "is an excellent example of how human disturbance can cause rapid evolution and affect biodiversity." Mauro plans to breed *H. cydno* "ghosts" and set them free. He wants to reestablish them in the remaining fragments of rich montane forest where some *Elzunia* still fly.

It is said that a butterfly can, with a flap of its wings, change the world—that the ripple it sends out can spawn a hurricane. True or not, passion vine butterflies have changed my world. As I have unlocked a few of their secrets, I have come to see them as embodying all the beauty and complexity of nature itself. I hope Mauro succeeds—for rarely, if ever, do we get the chance to restore to nature even a tiny part of what we have taken away. □

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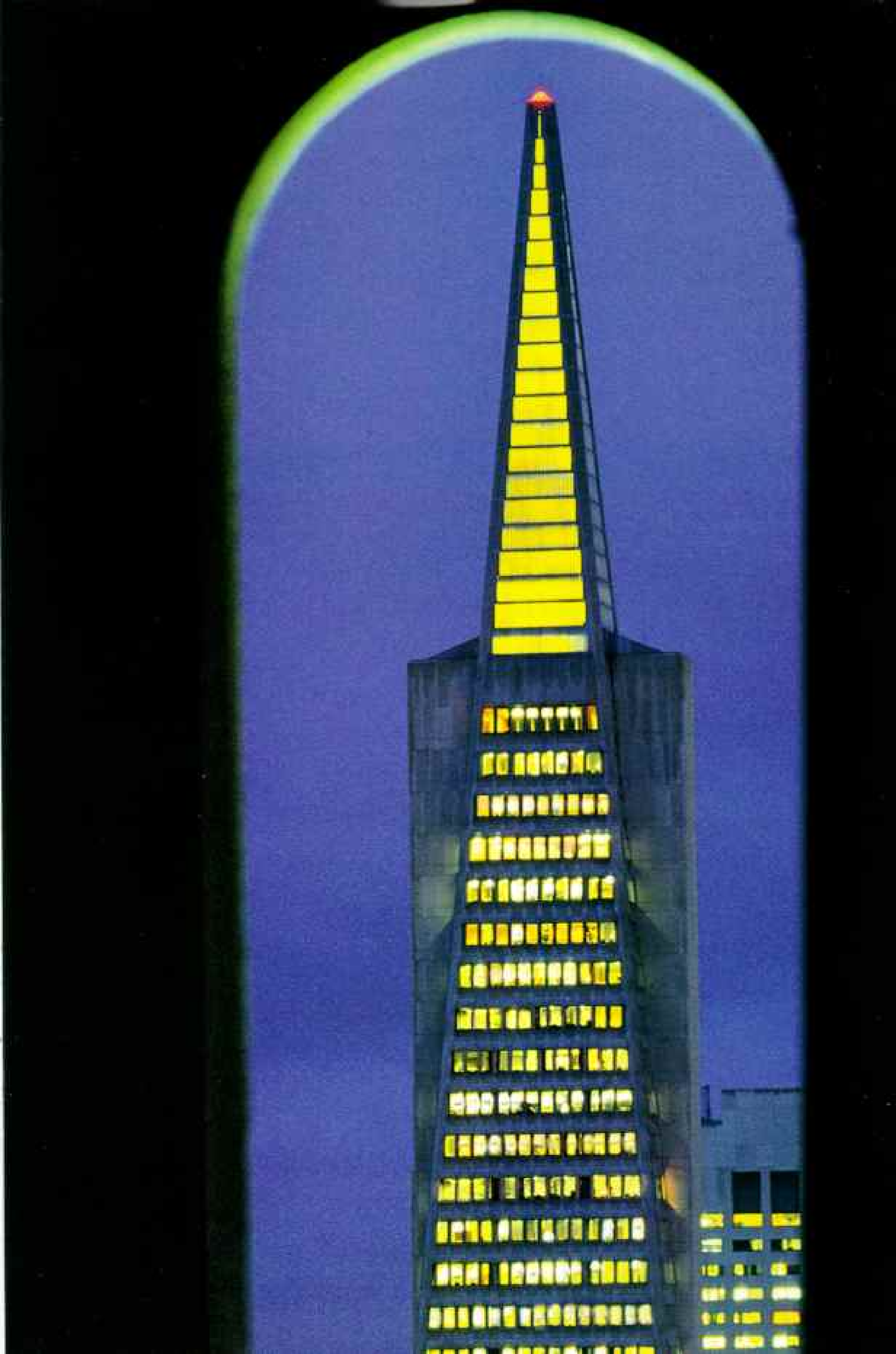

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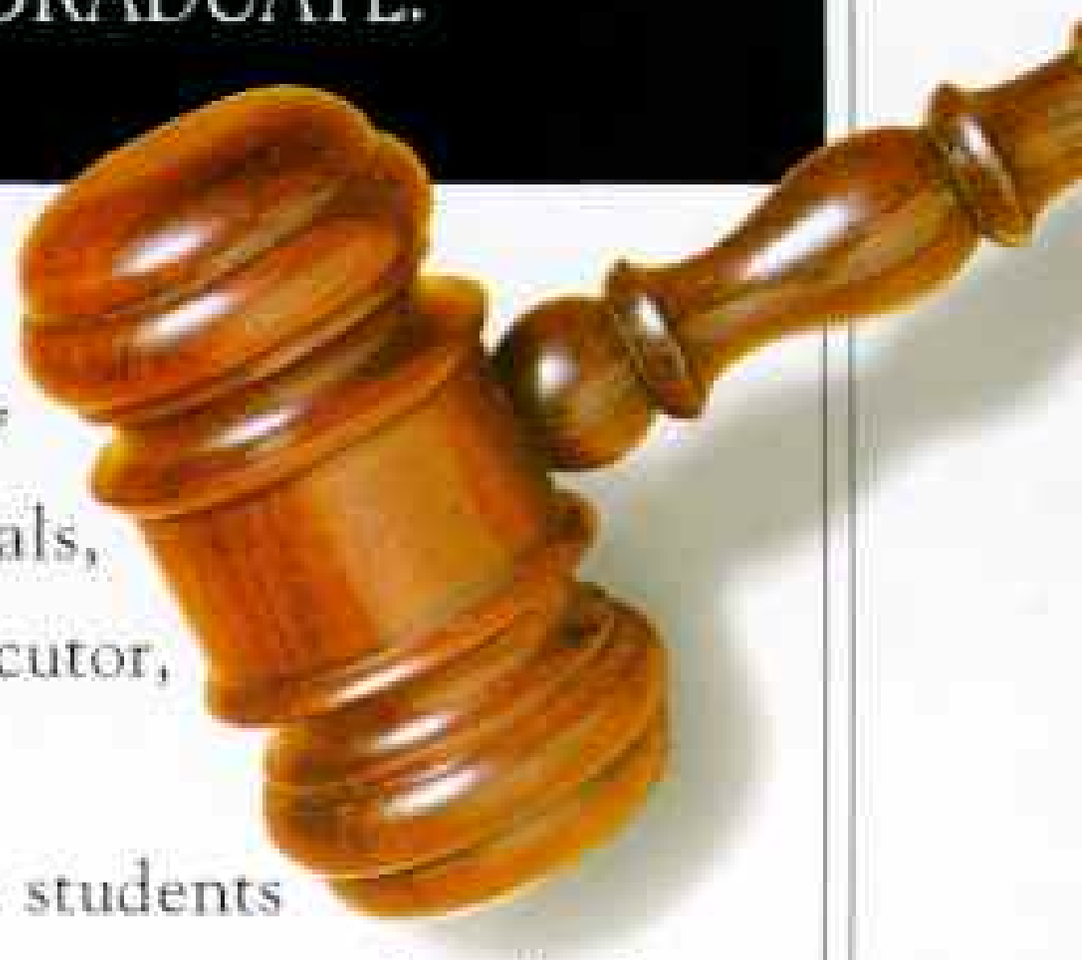
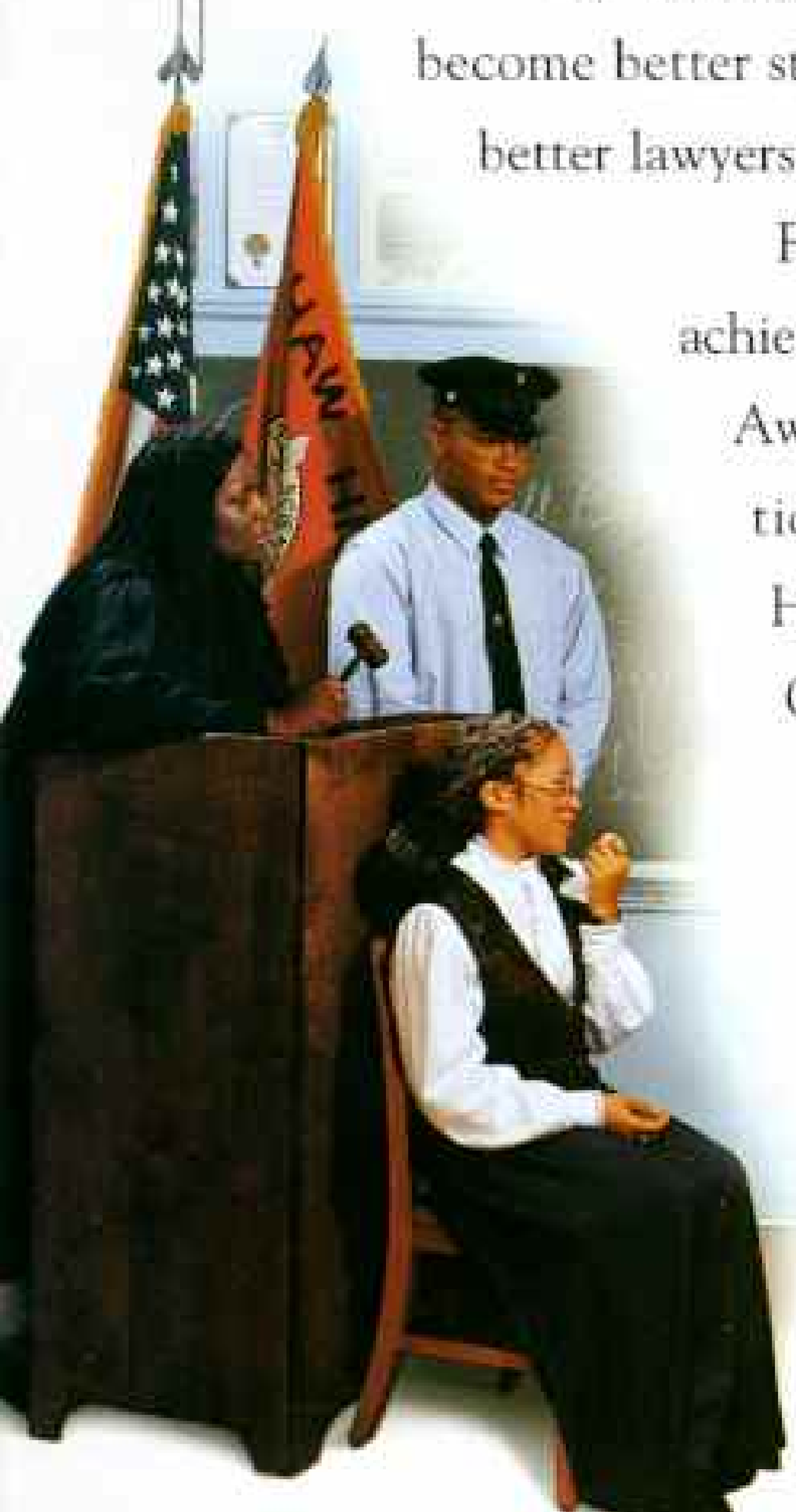


Lori Urogdy Eiler frequently holds court in her high school law class. Her students stage mock trials, playing the roles of defendant, prosecutor, and public defender.

Why? Because Lori feels her students best achieve by doing. That's important in a school where creative resources must far exceed budgets.

By thinking in new and different ways, they become better students. Better citizens. Not to mention better lawyers and judges.

For educational methods that truly inspire achievement, Lori receives the Good Neighbor Award, along with a contribution of $5,000 to Shaw High School of East Cleveland, Ohio.



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THE PRESIDENT'S REPORT ON THE

Education Foundation

STUART FRANKLIN (ABOVE); JAY DICKMAN

Kids and Teachers Show Their Mettle

If the young men above seem immersed in serious business, it's because nothing less than the honor of the United States is at stake. The trio had battled from behind to move within reach of victory at the first International Geography Olympiad, which matched the U. S. against teams from the United Kingdom and Russia. The Society and Citibank cosponsored the London event.

I can tell you that most adults in the audience at the Royal Geographical Society last July 2 were scratching their heads over a final-round question from moderator Alex Trebek: What river of 4,200 kilometers (2,600 miles) rises in the Tangla Mountains of central China?

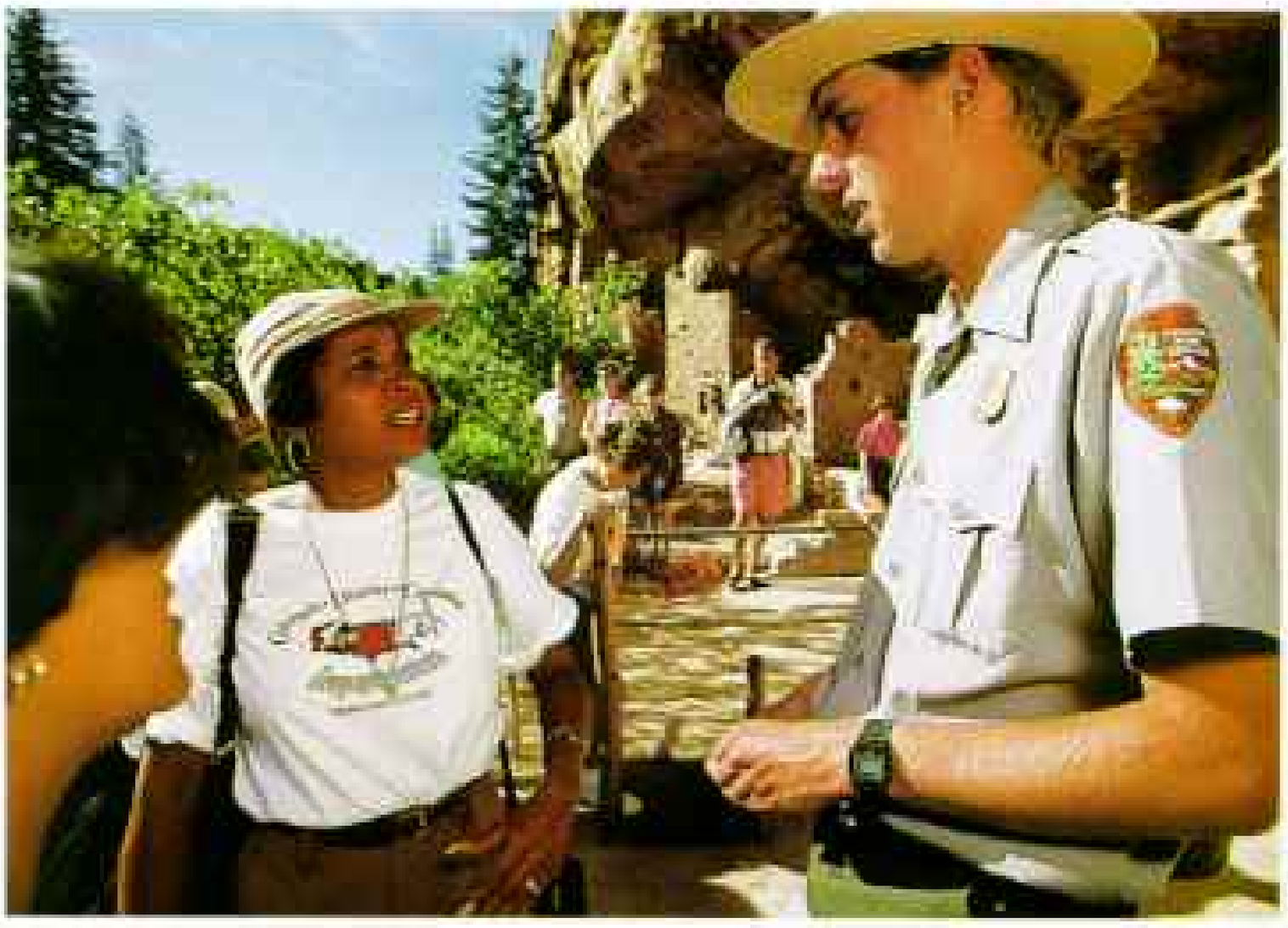
The winning U. S. team came up with the answer: the Mekong.

"It was great to meet the kids from other countries," says Noel Erinjeri, 14, of Flint, Michigan. "We're sending pictures and letters back and forth already." Noel, along with Michael Ring, 14, of Woonsocket, Rhode Island, and Jeffrey Hoppes, 13, of Lancaster, Pennsylvania, were the top finishers in the National Geography Bee.

Just after the three young Americans returned from London, 28 geography teachers from Washington, D. C., traveled to Carbondale, Colorado, as part of our Geography Outreach Program. Thanks to the Morris and Gwendolyn Cafritz Foundation and Amtrak, they had two weeks of intensive geographic skill development. "I haven't worked so hard since college!" declared Yvonne Bess (below), who quizzed a park ranger about the cliff dwellings at Mesa Verde.

Who knows—perhaps Yvonne and company will nurture future Geography Olympiad winners.

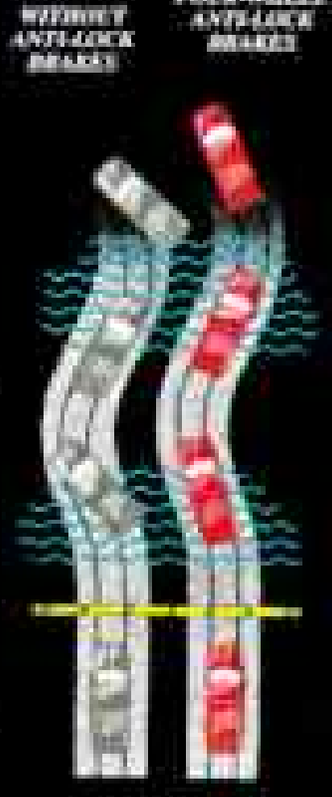
Gilbert M. Grosvenor



INTRODUCING *MOTOR TREND'S* "TRUCK

To hear the editors of *Motor Trend* talk about the new Dodge Ram is to realize the rules have changed. They proclaimed the Ram to be "...a new standard by which full-size pickups will be judged." And declared it "...a force with which to be reckoned." Our sentiments exactly.

Dodge Magnum series V-6, V-8 and Cummins Turbo Diesel engines wrote the book on power. And with the new Ram's available Magnum V-10†, they're getting two cylinders better. To the tune of 450 lb ft of torque and 300 horsepower.



Ram makes a powerful statement when it comes to safety, too. It has one safety feature no full-size pickup ever had before. A standard driver's airbag.* There's also available four-wheel anti-lock brakes. Along with high-strength steel door beams. And a dozen other safety features.

There's no rule saying trucks have to ride like trucks. That's why we gave our new Dodge Ram a new frame and improved suspension travel. We just wouldn't hear of making a noisy pickup, either. Fact is, we worked very hard to make our new Ram a standard for quietness.

Sure, pickups have always been workhorses. Now

OF THE YEAR."

they're a convenient place to conduct business. With an available center console between the front seats. Behind the seats, there's plenty of room for an ingenious optional storage system. And back in the bed, you'll find a set of tie downs so well engineered, they can support the weight of the entire truck.

We've provided an extra measure of protection, too – using more exterior galvanized steel than any other full-size pickup on the road, and making substantial use of anti-chip materials.

Here's one last point to consider: Ram also has more maximum payload than other full-size pickups. Not to mention the terrific amount of weight it carries...with the editors of *Motor Trend*.

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Forum

Sweden

Don Belt's informative article on Sweden (August 1993) made me recall a country and people that I so much enjoyed on past visits. But what justifies the subtitle, "In Search of a New Model"? Sweden's progressive society and political-economic system constituted a model for other nations in the past and will continue to do so in the future, I am sure. Despite its new, more conservative government, which is still far to the left of the Clinton Administration, Sweden will retain its economic democracy with its strong welfare safety net. Is it envy or insecurity that causes us to take potshots (alcoholism, suicide rate, lack of initiative and ambition, etc.) at Sweden's way of life, which is in many ways superior to ours?

LAWRENCE M. FISCHBACH
Fresno, California

We were promised a heaven that combined the wealth of a market economy with the "caring" of a socialist state. But the economy stopped growing, and the government could never replace the caring that only family and close friends can give. The welfare state was nothing more than a socialist dream—disastrous for business and economic growth. We are abruptly awakened with the harsh reality of broken promises and tax rates that can exceed 65 percent.

NILS HAST
Stockholm, Sweden

I am a 21-year-old average Swedish guy about to finish my military service, mandatory for all Swedish men over 17. You pinpointed the problems that Sweden is facing in many areas. I especially appreciate the background history and the discussion of Olof Palme's murder as a milestone for the Swedish model. But when Belt says that we lump all foreigners under the term *invandrare*, I can only refer to my time in the U. S. as a high school student, when I was called "alien." I would prefer being called invandrare instead of being associated with monsters from outer space. The very good picture on pages 20-21 is not at all representative of modern Sweden but might be for 50 years ago. Also the ending quote sounds like a line from one of Ingmar Bergman's surrealistic films. I think the diagnosis for Sweden was too pessimistic.

MAX FLORENIUS
Karlskoga, Sweden

How interesting is the picture of skinheads wearing T-shirts that bear the logo of the old Cotton Belt Route and the legend "White Only" (pages 26-7). In the early 1900s my family lived across the street from the rails of the Cotton Belt—officially the St. Louis Southwestern Railway Company. Much has changed since then. The Cotton Belt has been absorbed by the Southern Pacific, and I noticed a black engineer and conductor on board the last time I visited Tyler, Texas. The logo's outline is that of a cogwheel on a cotton gin that bales ginned cotton into 500-pound wrapped bales.

JULIAN MARDOCK
Dallas, Texas

The biggest shame of the Swedish government after World War II was that it turned over German soldiers who sought asylum there to the Russians, even soldiers who deserted from the German Army during the war. Many tried to commit suicide or to mangle themselves. Even the sick and invalided were carried aboard Russian vessels. Most disappeared without a trace in Stalin's gulag.

EDUARD ORSECH
Ratingen, Germany

Before we American readers smugly compare our vaunted pursuit of excellence with the *lagom* aspirations of under-40 Swedes, we should note one thing. The average lagom Swedish plumber, electrician, mechanic, industrial trainer, or software engineer (my field) is noticeably more skilled than his or her American counterpart—better trained, more current, and more meticulous. My years in and near Sweden taught me that the standard of lagom usually exceeds what passes as excellent here in the U.S.A. We should all be so lagom.

JIM TRUEBLOOD
Atlanta, Georgia

Bacteria

As a recent university graduate in biochemistry, I have had the pleasure of studying bacteria in many courses and continue to be fascinated by their size, complexity, and beauty. Thomas Y. Canby's stimulating article did not sufficiently credit *Thermus aquaticus*, a bacterium that lives in hot springs. It has revolutionized the analysis of DNA by laboratories around the world through its use in a gene amplification technique known as polymerase chain reaction (PCR). This technique, devised by Kary Mullis and colleagues at the Cetus Corporation in Emeryville, California, literally amplifies small amounts of DNA by using a heat-stable enzyme from the bacterium. PCR has been used to amplify ancient DNA and DNA left in blood, semen, and hair at crime scenes for DNA comparisons.

DAVID PANKIW
Lorraine, Quebec

To Operate This Highly Advanced Training Equipment, It Takes A System Of Sensitive Counterweights, Reinforced Suspension Cables,

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Each time you use your Visa® card, Visa donates money to help provide the '94 U.S. Olympic Team with the most advanced training available. Like this wind tunnel, where U.S. ski jumpers can get years of experience during each practice session. So use your Visa card – the only card accepted at the '94 Winter Olympic Games. There's no better way to help train our Olympic athletes. Unless, of course, you know how to operate a Calspan high velocity wind tunnel.

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Like Spain, mid-18th-century England had an important chemical industry using microbes. Pyrite (fool's gold), eroded from coastal cliffs, was shipped to London and spread over outdoor platforms to be decomposed by bacteria. Rainfall seeping through became copperas (ferrous sulfate solution), which, when boiled and crystallized, was widely exported as "green English" for making sulfuric acid.

MICHAEL S. COTTERILL
Freshwater, Isle of Wight

In the literature on genetic engineering, possible problems arising from the genetic alteration of species and their subsequent release into the environment are consistently downplayed. We have no working model suggesting that these procedures are safe. The use of recombinant organisms in controlled environments has delivered valuable results, such as Humulin and interleukin. But releasing large numbers of mutants into the ecosystem without full understanding of the possible consequences is irresponsible. We need to look carefully at how this technology is used lest the human race find itself once again emerging from the primordial pond.

CANDACE SAYLOR
Livonia, Michigan

Horn of Africa

Robert Caputo's article touched me to the core and transported me back to lands, people, and feelings that infiltrate my dreams. In November 1992 I left my job to work as an emergency medical relief officer in Bardera, a small town completely destroyed by the tragedy still afflicting Somalia today. I spent six months watching those beautiful people move from sheer desperation to hope and back to fear again. We provided food and medicine; we filled bellies and healed wounds. We helped plant their fields and clean their water, but we also left them to deal with their orphans, anger, and inoperative social structures. I watched their dreams destroyed. If I could wish one thing for them it would be *nubud*—Somali for "peace."

MARCY S. GELMAN
Pittsburgh, Pennsylvania

The article subtly perpetuates the widespread myth that drugs cause antisocial behavior. The mild stimulant kat, or *Catha edulis*, is consumed across social classes by a majority on both sides of the Gulf of Aden, much as tea is consumed by the British. Since kat is taken by both the law-abiding and the anarchic, the despicable behavior of the "young Somalis high on kat who stole . . . and terrorized" cannot be said to be caused by kat. Drugs are only the proximal cause of behavior, not the underlying—and infinitely more important—social one.

NEY LOPEZ, JR.
Tempe, Arizona

National Geographic, December 1993

Tie one on.

This holiday season, some 150 million people will "Tie One On For Safety"™ by attaching a bright red ribbon to their car antenna or side mirror. It's part of an overall effort developed by MADD (Mothers Against Drunk Driving) and sponsored by The Good Hands People of Allstate, promoting safe, sober driving.

See your Allstate Agent now for your complimentary red ribbon, and tie one on to express your commitment to make our roads safer for everyone. Working together, we can help ensure a safe and jolly holiday. And many more happy new years.

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WILDLIFE AS CANON SEES IT

Wolverine
Genus: *Gulo*
Species: *gulo*
Adult size:
Length, 65 – 105 cm;
tail, 17 – 26 cm
Adult weight: 14 – 21 kg
Habitat: Varying types from northern forests to tundra in Europe, Asia and North America
Surviving number:
Unknown
Photographed by
Antti Leinonen

Living only in the remotest areas, the wolverine has been described as "an animal of the solitudes." Though noted for its prodigious strength and survival abilities, this predator and scavenger remains largely unknown in the scientific sense due to its far-ranging and elusive nature. As its habitat continues to shrink, the wolverine has become symbolic of the world's rapidly dwindling wilderness. To save endangered species, it is essential to protect their habitats and understand the vital role of each species within the earth's ecosystems. Photography, both as a scientific research tool and as a means of communication, can help promote a greater awareness and understanding of the wolverine and our entire wildlife heritage.

EOS 1
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NATURE

Watch "NATURE" on PBS, Sunday 8:00 p.m.
This program is funded, in part, by Canon U.S.A., Inc.

Canon

As an Eritrean living in the States, I would like to thank Robert Caputo for his matter-of-fact and up-to-date article. It's been a long time (May 1983 and September 1985) since I saw a GEOGRAPHIC report about that unfortunate region of the world. Despite the failure of the West to reward their success, the Eritreans—having paid dearly for the past 30 years—will rebuild their nation alone and become the bright future of East Africa.

SAMSON TEKLE
Boston, Massachusetts

Tibet's Chang Tang Reserve

Your article discusses the recent negative impact of human beings on the environment in Chang Tang and in Tibet as a whole without indicating the source of the problem. Only since China's occupation of Tibet have mining, road construction, and other development been pursued in earnest. Chinese efforts to "develop" Tibet are the direct cause of the animal exterminations you describe. The Dalai Lama, if reinstated, would turn the entire country into a wildlife preserve, in keeping with Buddhist traditions regarding the sanctity of all life. However, the most endangered species in Tibet is the Tibetan Buddhist. It appears that Tibetans are now a minority in their own capital, and only a handful of the thousands of Buddhist temples that once dotted the high plateau remain.

RAY SCANLAN
Phoenix, Arizona

My first acquaintance with the Chang Tang plateau was in Heinrich Harrer's *Seven Years in Tibet*. Against all odds, Harrer escaped a POW camp in British India in 1944 and traversed Tibet only to be beset by bandits, cold, and starvation. Harrer lived in Lhasa until the Communist Chinese invasion in 1950. His descriptions of Tibetan life, customs, and people provide a window on a vanished world.

MARGARET M. MAHER
Sacramento, California

Geographica

In the article comparing Stone Age foragers with peoples of industrial societies in terms of cancer risk, I think it is presumptive to conclude that the differences in diet and lifestyle have anything whatsoever to do with rates of cancer in the two societies. There are too many other variables and no controls. The Kung San are probably more homogeneous genetically and may have an inherited resistance to certain cancers. There are also environmental differences such as less exposure to pesticides.

KIRSTEN LLAMAS
Miami, Florida

Letters should be addressed to FORUM, National Geographic Magazine, Box 37448, Washington, D. C. 20013-7448, and should include the sender's address and telephone number. Not all letters can be used. Those that are will often be edited and excerpted.

Forum

The Not So

Because It Has So Much. *True. It looks like a minivan. But when you consider everything Chevy Astro comes with, including its bigger, truck-like feel and its solid, truck-like performance, "minivan" is probably a misnomer. For starters, a driver's-side facial air bag* ◊ *is standard. And for greater stopping control, even through sharp, slippery curves, 4-wheel anti-lock brakes come not as an option, but also as standard equipment. Add to this optional All-Wheel Drive for greater traction, and you have a vehicle with an extraordinary range of safety features.*

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Mini Van.

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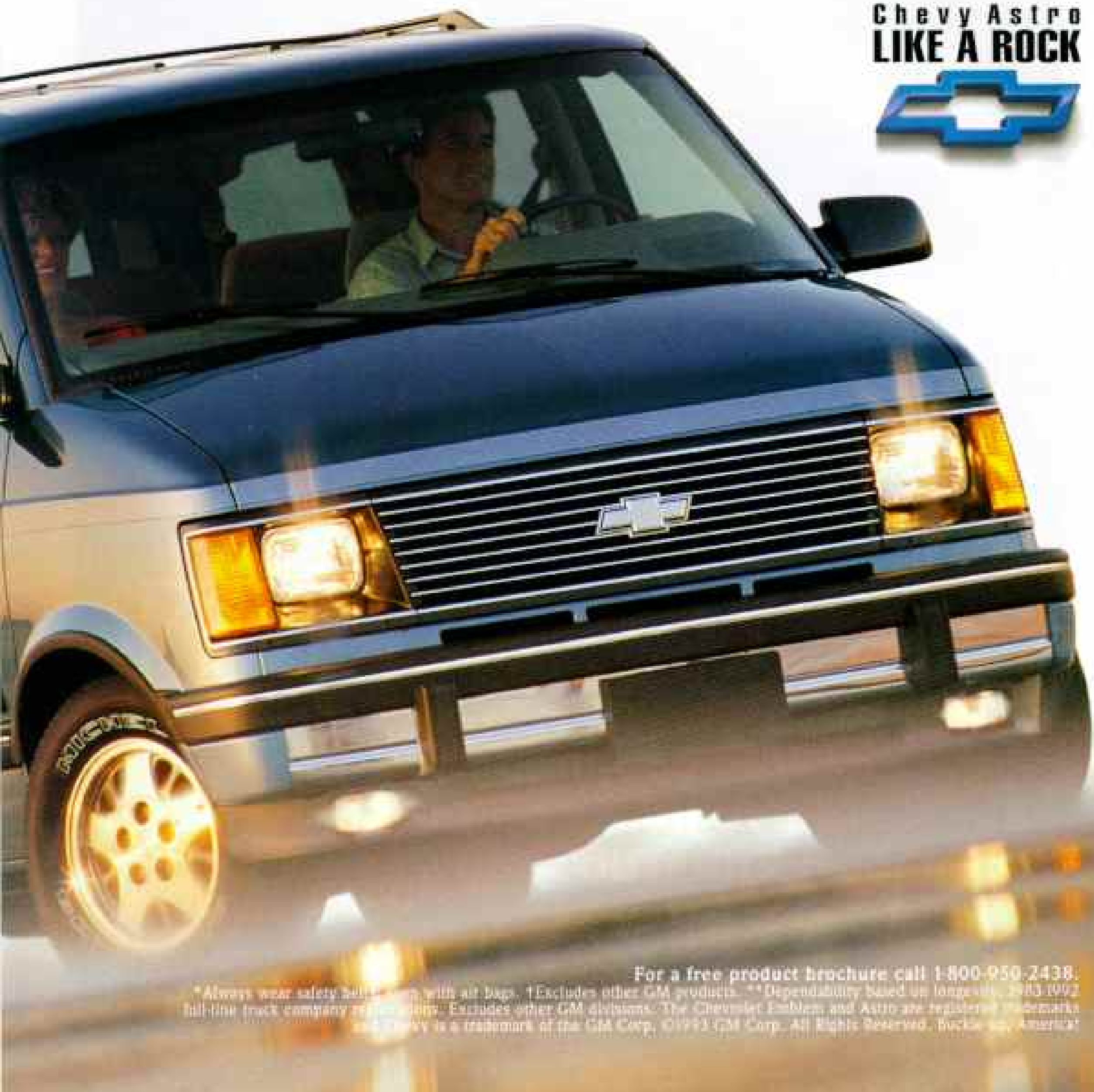

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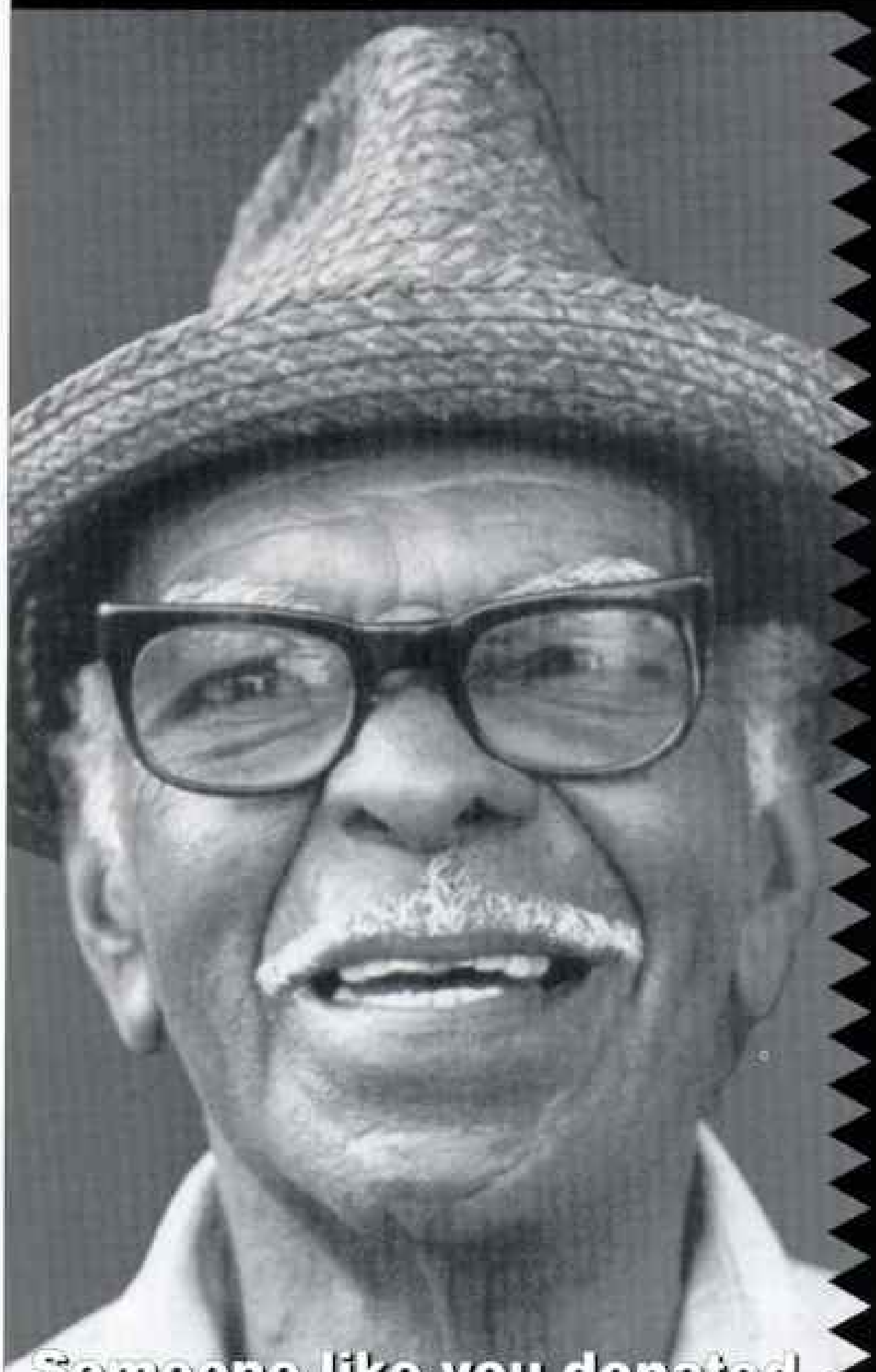

"We gave glasses to Eduardo who had never before seen clearly. He put them on and started pointing at his family shouting, 'I can see my grandchildren!' It was unbelievable!" Deborah Stiner, LensCrafters Associate/Mission Team Member

Worldwide, 1.5 billion people need glasses and millions in developing countries have little hope of affording them.

Give the Gift of Sight is an eyeglasses recycling program sponsored annually by LensCrafters and Lions Clubs International to provide free eyecare and used glasses to needy people throughout the world.

Call 1-800-541-LENS for a LensCrafters location near you.

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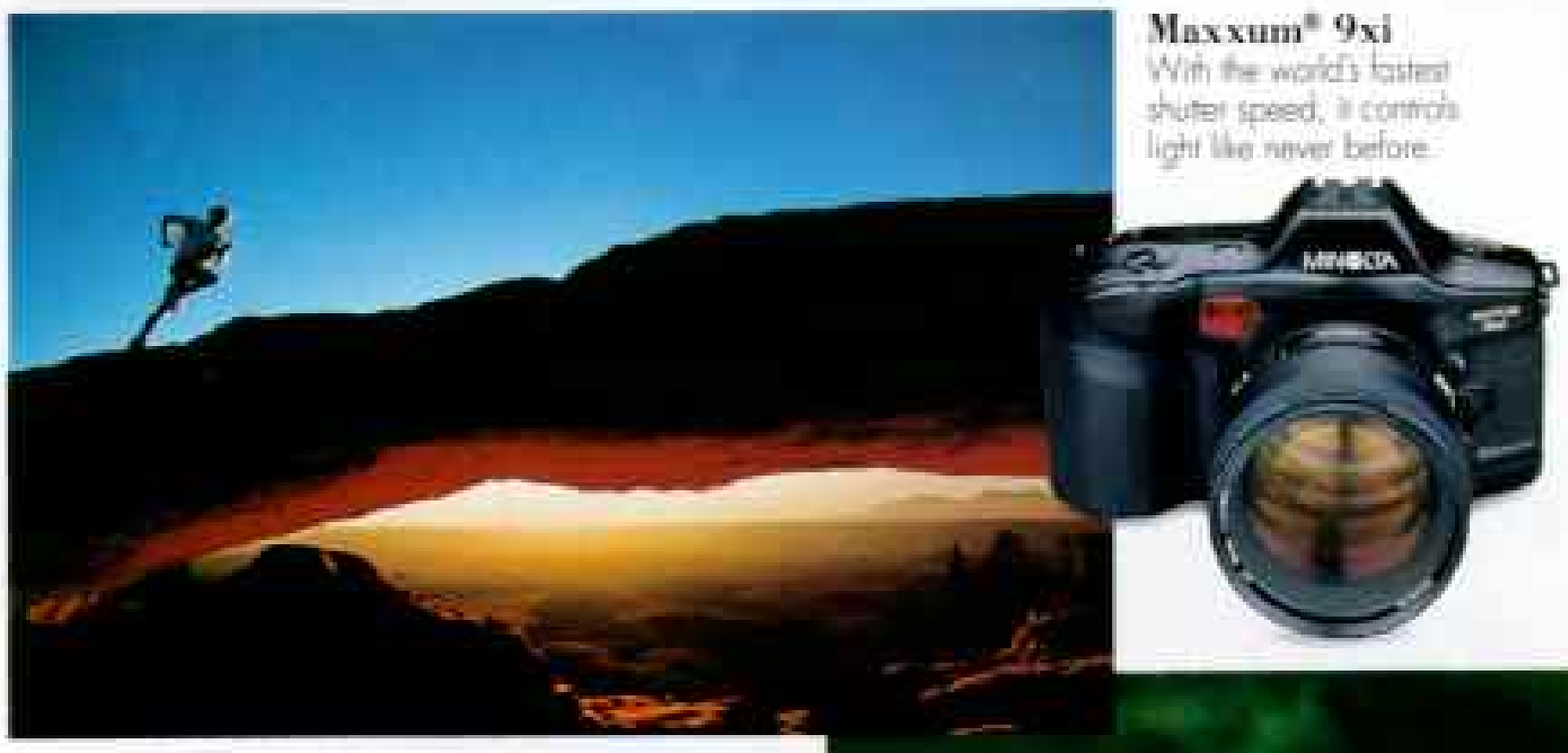
MOTOROLA

Many visions, only one mind.



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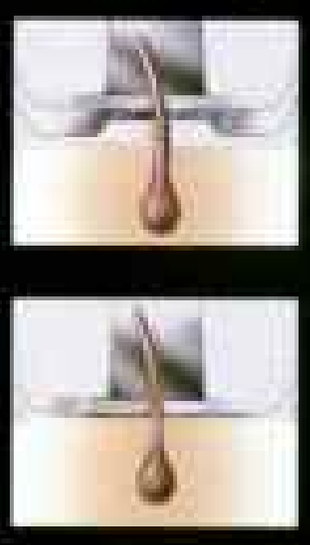

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Geographica

Intertwined Lives Go On in Andrew's Wake

Our April 1993 cover summed up the aftermath of Hurricane Andrew—and tugged at readers' hearts too. Joel Sartore's photograph of a marine comforting a Florida City boy made homeless by the storm drew an exceptionally emotional response.

"I've seen many touching pictures in my life, but this one sure ranks with the top," a reader wrote. It "reminded the heart what living's about," wrote another.

Marine David Ketcham was walking through a relief center in September 1992 when three-year-old Jarvis Williams came up to chat. "I made it a point to see him two or three times a day," says Ketcham. "He took my mind off the tent city." Ketcham, now 21 years old, has completed artillery training on Okinawa and has been promoted to lance corporal. Here he visits with his father, Lloyd, in Delphos, Ohio (right).

Meanwhile, Jarvis Williams (top, with baby brother David) has found a home in Miami, has celebrated his fifth birthday, and according to his mother, Sylvia, "is coming along fine," . . . except when a storm incites fears of Andrew's return.

"I want to see the Marines again," Jarvis tells his mother, "but not if there's a hurricane."

SUSAN BIDDLE (BELOW); DIXIE KEREEN

Beetle Plays Scrooge to Christmas Tree Industry

Christmas tree growers around the Great Lakes face a distinctly unmerry Christmas season if an alien insect continues its invasion.

The pine shoot beetle, *Tomicus piniperda*, a native of Europe and Asia, breeds in the slash and stumps of cut pine trees, especially Scotch pines. It was discovered in the United States in 1992, apparently having hitchhiked in the bark of trees in a European cargo ship that docked at Cleveland. By last September the insect had turned up in 88 counties in Ohio, Pennsylvania, New York, Illinois, Indiana, and Michigan, and in Ontario; experts expect to find it in surrounding areas as they continue their search.

"Scotch pine is the number one host of this beetle in the old country," says Robert Haack, a U. S. Forest Service research entomologist. "More than 60 percent of the Christmas trees grown in the Great Lakes region are Scotch pine, so it's an ideal setting for the beetle."

After maturing, the match-head-size insect tunnels out through the bark of its host tree and flies to feed on lateral shoots at the top of nearby pines. One beetle can kill six shoots a year, Haack says. Unchecked, an infestation may disfigure trees or stunt their growth.

The U. S. Department of Agriculture has banned shipments of infested trees to "clean" areas—bad economic news for growers, who ship millions of trees during the holiday season.


Nissan Quest GXE

"When I was your age we didn't have our own captain's chairs, air conditioning controls and headphone jacks."

Some say today's kids are spoiled. They've never trudged ten miles in the snow to get to school. Never worked the coal mines from sun up to sundown. And frankly, never had it hard enough to appreciate the comforts to which they have grown so accustomed.

You, however, having spent your formative years in a wood-panelled station wagon, will appreciate the Nissan® Quest™ GXE for the uncommonly luxurious minivan that it is.

You see, unlike other manufacturers who typically design from the outside and build their way in, we reversed the formula and worked our way out.

The benefit becomes evident the minute you plant yourself in the driver's seat. Which adjusts electronically to a near infinite number of positions. We even gave the seat an inflatable lumbar mechanism for greater support in the lower back (an area parents tell us is easily aggravated).

If you think we were innovative with the driver's seat, you should see what we've done with the other six.

Slide open the side door and you will discover a second row of optional leather-appointed captain's chairs† plus a rear three-seat bench mounted on QUEST TRAC™, our flexible seating system that allows up to 24 different configurations.

At this point, our engineers thought, "If we can design a minivan that feels like a car, why not a minivan that maneuvers like one?"

So, after furnishing the Quest with an 8-speaker stereo system,† power sunroof,† and cruise control, they equipped it with a powerful V6 engine, front-wheel drive and a stabilizer bar that helps eliminate swaying motion.

Of course, the best way to experience the Quest is to test-drive one. And feel free to bring the kids. If they don't want to come, gently remind them that "as long as you live under my roof, you'll do as I say."

If you'd like additional information please call 1-800-NISSAN-3, ext. 257.

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Nissan Motor Corporation U.S.A. Smart people always read the fine print. And they always wear their seat belts. Requires luxury package. †Optional luxury package available on Quest GXE. ‡Optional equipment available on the GXE model.

Geographica

PAINTING BY DAVID MEITZER

Day 1 of the Ancient Chinese Calendar

Five planets were "lined up like a string of pearls" near the constellation Pegasus at dawn on the first day of spring. Soon the sun and the new moon also came into alignment. It was that auspicious once-in-10,000-years day, claims Jet Propulsion Laboratory astronomer Kevin D. Pang, that the ancient Chinese chose as the beginning of their calendar.

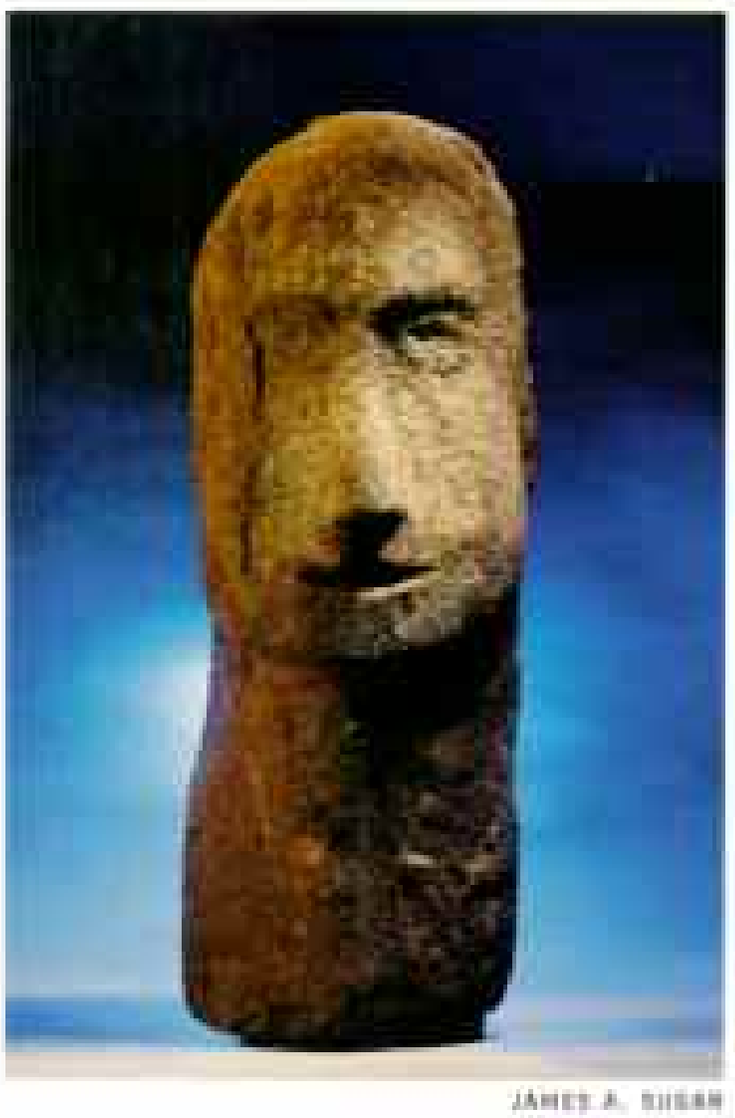
The date was lost as records vanished and emperors made adjustments to the calendar. Then in 1985 David Pankenier, a scholar of Chinese history at Lehigh University, determined that the rare conjunction of the planets—which he linked with the beginning of the rule of Yu, first emperor of the Xia dynasty—occurred on February 26, 1953 B.C.

Now Pang, using a first-century B.C. text and a computer program that pinpoints the location of heavenly bodies thousands of years ago, has discovered that just eight days later the sun and moon joined the aligned planets. That "magic moment," he believes, was recorded as the first day of the Chinese calendar: March 5, 1953 B.C.

Going Head-to-Head With Indian Prehistory

"I lifted a piece of sandstone about the size of a loaf of bread," recalls Grace Rajnovich, who was excavating a thousand-year-old trash heap in the Gottschall rock-shelter in southwest Wisconsin. "I turned it over and found someone staring back at me. My knees started quivering, my legs caved in."

Archaeologists would not be surprised to find the ten-inch-high carved and painted sandstone head (left) at Mound Builder sites, such as Spiro Mound in Oklahoma or Cahokia in Illinois. But its discovery hundreds of miles from the major centers of Mississippian culture was totally unexpected. The find buttresses the theory of Robert Salzer of Beloit College that the site was a shrine used by ancestors of the region's Winnebago people. He believes the head represents the revered figure Red Horn, also known as He Who Wears Human Heads as Earrings. Paintings on the shelter walls depict events from the Winnebago legend surrounding Red Horn as athlete, warrior, and elder.



JAMES A. SUGAR

A Volcano "Emerges" on the Ocean Bottom

Oceanographers long have known that erupting lava along the Mid-Atlantic Ridge produces new ocean crust. In the 1980s, sonar maps of the valley floor showed circular features some scientists thought were volcanoes. But others said the details were not clear enough to tell.

A new sonar device towed 10,000 feet below the ocean surface has produced high-resolution images (above) that seem to end the debate. "If you asked a child to draw a bird's-eye picture of a volcano, this is what he would draw," says Joe Cann of Britain's University of Leeds. The sophisticated sonar, towed by the British research vessel *Charles Darwin*, "flew" a few hundred feet above the summit, which tops out 650 feet above the ocean floor.

DEBORAH SMITH, WOODS HOLE OCEANOGRAPHIC INSTITUTION, AND JOE CANN, UNIVERSITY OF LEEDS

National Geographic, December 1993

If You Never Thought Of Your Child As The Military Type, Think Again.

Now is the perfect time to think about what the military has to offer.

Although the military is getting smaller, the Armed Forces still need to recruit almost 400,000 young men and women for Active and Reserve positions each year.

Education, training, and job experience are important parts of the plan to restructure today's Armed Forces. They are also exactly what tomorrow's employers will be seeking.

Today's military is one of the most sophisticated and technologically advanced organizations in the world.

As in the past, the opportunities and rewards for joining the military will continue.

So, if you know a smart, ambitious high school graduate who's determined to make the most of the future, maybe he or she is the military type after all.

U.S. Armed Forces

ARMY ★ NAVY ★ AIR FORCE ★
MARINES ★ COAST GUARD ★

Geographica

Green Icebergs Reveal Their True Colors

For years travelers in Antarctic waters have reported seeing green icebergs—a departure from ordinary bluish white ones. Some scientists thought the color was an optical illusion, caused by a low red sun; others insisted the bergs were green.

Now spectral analysis of a green iceberg near the Amery Ice Shelf proves that such icebergs truly are green. Normal Antarctic icebergs consist of snow compressed into glacial ice, which flows out onto the sea to form ice shelves. Hundreds of feet below the surface, Antarctic seawater freezes to the bottom of some shelves. Where the seawater is biologically rich, the ice includes the dissolved remains of plankton.

BERNHARD DIECKMANN

When green icebergs become top-heavy and capsize, they reveal their colored undersides. Fewer than one in a hundred Antarctic icebergs is green, reports Stephen Warren of the University of Washington, a member of an Australian team investigating the subject. And the more organic matter, the greener the iceberg. "The color is inherent to the ice," says Warren.

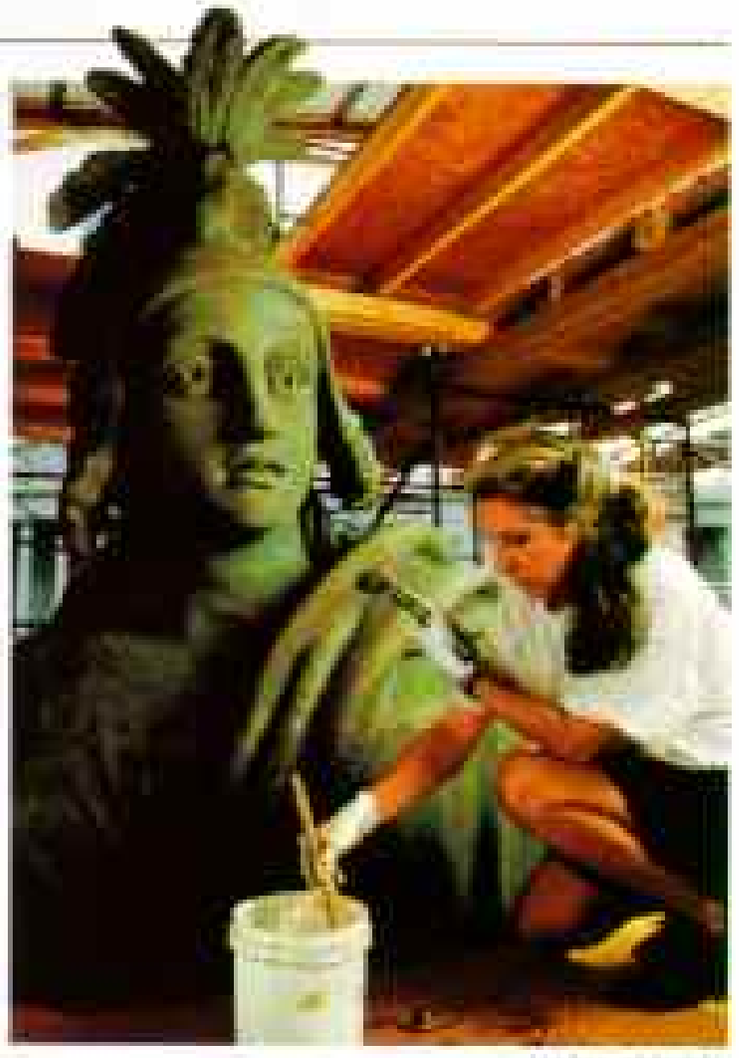
A TALE OF TWO STATUES

A New Memorial Honors Women Vietnam Vets . . .

Three military women in bronze left sculptor Glenna Goodacre's studio in Santa Fe, New Mexico (below), last August on a national tour en route to Washington, D. C. One comforts a wounded soldier, another holds a helmet, a third looks to the sky. They will face the Vietnam Veterans Memorial; its black walls list eight female nurses among the 58,191 names of those who died in the war.

The Vietnam Women's Memorial honors the 265,000 women who served during that war, including 11,000 in Vietnam. It will join a statue of three military men. "That statue is beautiful, but I was struck by the absence of a woman," says Diane Carlson Evans, an army nurse who tended wounded in Vietnam and has fought for the memorial since 1984. "At first most women who served didn't want to talk about it. Now future generations will learn that women were there, often hearing a GI's last call for his mother."

"Nine years in the making, more than 20 years in the needing," said Gen. Colin L. Powell of the statue. "The circle of healing will now be complete."



MARIA STENZEL

. . . At 130 Years, Freedom Gets Her First Face-lift

No, she is not an Indian. The 1855 design for the statue of Freedom atop the U. S. Capitol dome originally included a "liberty cap." But Secretary of War Jefferson Davis thought the Roman symbol of a former slave inappropriate for a free people and urged a helmet instead. Sculptor Thomas Crawford added an eagle's head, talons, and feathers.

Feathers and all, Freedom was brought to earth last spring for cleaning and repairs for the first time since she was elevated in 1863. Conservator Linda Merk-Gould waterblasted away accumulated dirt and corrosion. Then she applied a new color patina (above) to eliminate the patchy look bronze statues have after casting or cleaning.

"Records say this one was 'bronze-green,' but what's that?" Merk-Gould had wondered. The answer came from bits of original color on the statue's robe and pedestal and from an early hand-colored postcard. Along with the re-created color, a corrosion inhibitor and protective coating went on before Freedom's return to the dome.

—BORIS WEINTRAUB

STEVE NORTHUP, THE SANTA FE NEW MEXICAN

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NATIONAL GEOGRAPHIC MAGAZINE

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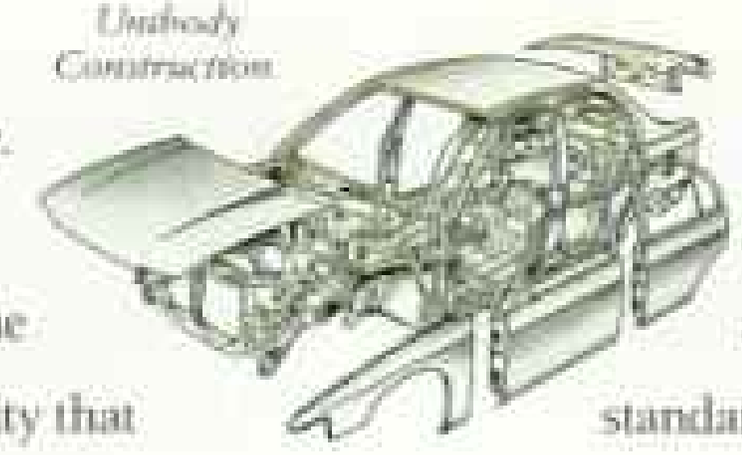
Offer is redeemable as discount on purchase or lease of a new GM car or truck. Up to $1,000 annually, to maximum of $7,000 over 7 years. No limit on Partner 5% Bonus during 7-year period. May be combined with other offers. Subject to GM Gold Card Rebate Program Rules. Mobil Partner Bonus not available in New Jersey. *There is no transaction fee for Hassle Checks; normal finance charges apply from the date of posting. GM Travel Services provided by Carlson Travel Group, Inc. ©1993 General Motors Corporation.

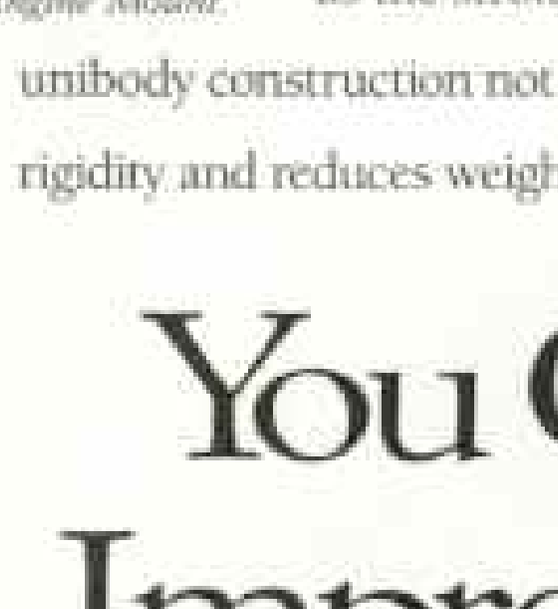


Unibody Construction

Some cars may offer more. Some cars may cost less. But only with Corolla do you get the unwavering dedication to quality that comes with its Toyota heritage.

If quiet is considered a measure of quality in a car, it's no wonder Corolla has acquired a reputation as the strong, silent type. Its unibody construction not only improves rigidity and reduces weight but it also helps minimize noise and vibration. Corolla's quiet ride and smoothness are enhanced even further by strategically placed sound insulation (sheets of asphalt and steel covered with a layer of heat-hardened resin) and a liquid-filled engine mount.

Liquid-Filled Engine Mount.



Three-Layer Sound Insulation.

Driver- and passenger-side air bags* are standard equipment as are ventilated front disc brakes with available Anti-lock Brake System (ABS). Corolla's air bag system even has gold-plated electrical connectors. Not just to impress, but for longer life and greater corrosion resistance.

*Dual Air Bags.**

Available Anti-lock Brakes

You Can't Buy A More Impressive Car For Less.

The goal was to make the best possible car at an affordable price. The result was Corolla. And for over twenty-five years it has been a benchmark of quality in America. That's impressive.

Call 1-800-GO-TOYOTA for a brochure and the location of your nearest Toyota Dealer.

Gold-Plated Electrical Connectors.

TOYOTA Corolla

"I love what you do for me."

*Always use your seatbelt. Driver- and passenger-side air bags are a Supplemental Restraint System (SRS). Buckle Up! Do it for those who love you. ©1993 Toyota Motor Sales, U.S.A., Inc.

Key to 1993

GRAND AM SPORT SEDAN

IT ALSO SPORTS A HIGH IQ.

■ Nothing could be smarter than the safety of its standard airbag and anti-lock brakes. ■ Or more exciting than the kick of its new, available V6 and agile sport suspension. ■ All for thousands less than Accord or Camry.* ■ And all backed by Pontiac Cares' 3-year/36,000-mile no-deductible bumper-to-bumper warranty,† free 24-hour Roadside Assistance and Courtesy Transportation. ■ So visit your Pontiac dealer for a test drive or call 1-800-762-4900 for more information. ■ And discover why Grand Am® is the fun choice and the smart one, too.

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*Price comparison based on MSRP of Honda Accord EX Sedan and Toyota Camry LE V6 Sedan. Level of equipment varies. †See your dealer for details of this limited warranty.

Always wear safety belts, even with airbags.

On Television

MARY ELLEN MARK

Growing Up Under India's Big Tops

Children everywhere dream of joining the circus. For a few young girls in India, the chance to become contortionists or acrobats in a traveling circus can be a springboard out of poverty.

"Circus of Dreams," a film produced for EXPLORER by Martin Bell and Mary Ellen Mark, delves into the exotic world of the Indian circus for a look at the life of a talented "plastic lady" named Pinky (above, at center).

Contracted to the circus at age three by her destitute mother, Pinky, now ten, practices hours daily. For the exercise *koti* she brings one leg to the ground, then raises it 200 times—while doing a handstand.

Trainer Pratap Singh and his wife, Sumi, instruct their young charges on washing, dressing, praying, playing, and performing. "We teach them to respect their costumes exactly like a musician respects his instrument," says Pratap. "Then God will lead you to the very top."

Circuses do not completely sever the children from their families. The film visits Pinky's mother and sister, who live in a rural village in the state of Maharashtra. Says her mother, "I have not made any mistake in sending her to the circus. It was in her fate to go." Pinky's family also depends on her earnings, which are sent home every month.

Mark—renowned for her still photography—and Bell, the film's director, traveled India with two circuses, compiling a visual anthology of spectacular acts for the film.

"Circus of Dreams" airs December 19 on EXPLORER, TBS Superstation, 9 p.m. ET.

Four Families Face Alaska's Wilds

They hunt caribou and moose in frigid wilderness. They gather berries while on alert for wolves and grizzlies. They lead lives of daunting isolation where winter temperatures can dive to 60 degrees below zero. "Braving Alaska," a National Geographic Special now available on home video, profiles four modern pioneer families.

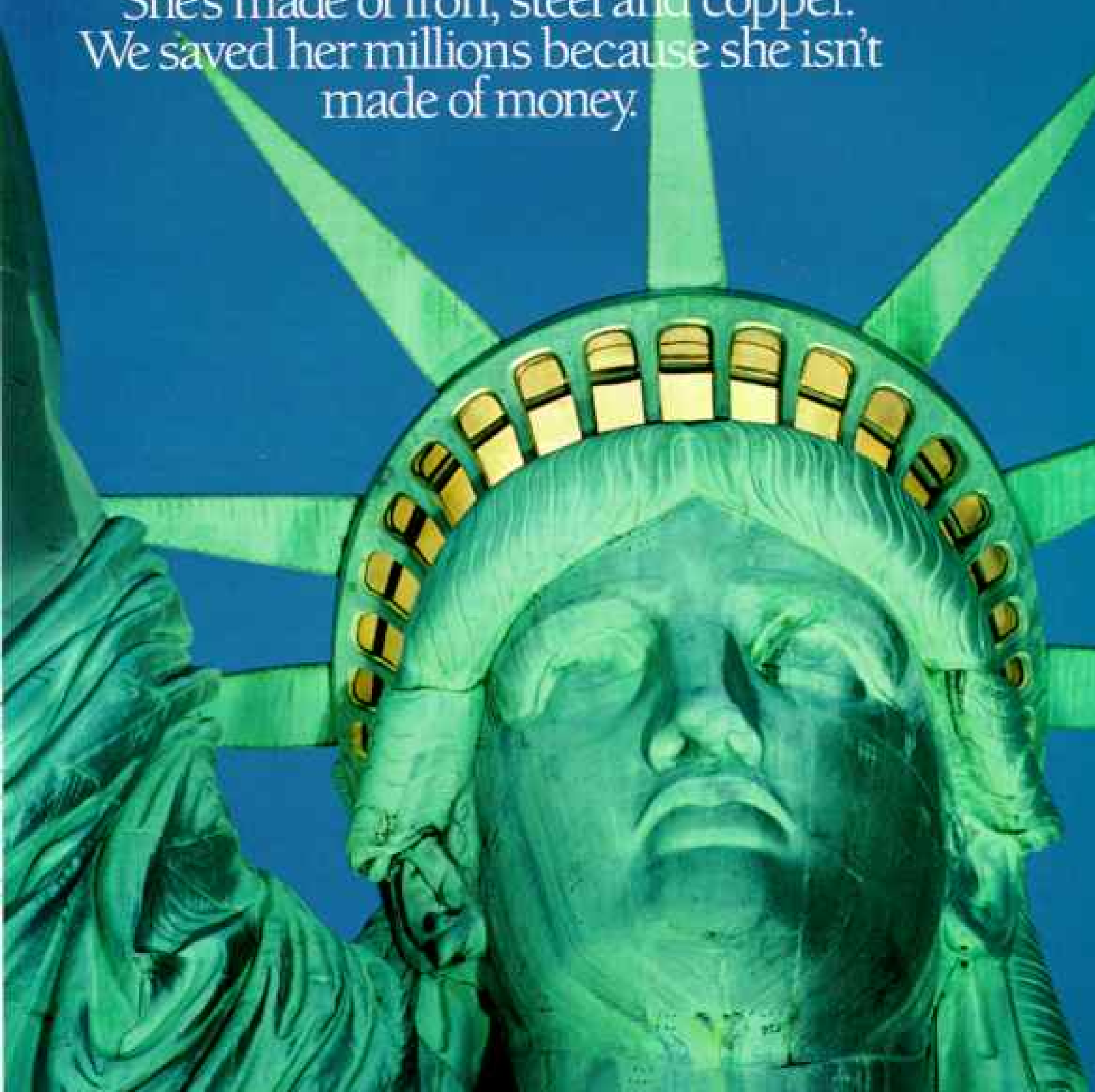
Mail arrives by bush plane three or four times a year; a radio is often the only link with the world. A video visit with the Korths, Haydens, Wilsons, and Browns reminds us of the essentials—and, when faced with the hundredth meal of moose meat, the value of a sense of humor.

"Braving Alaska" is a December selection of the National Geographic Video Club.

Recently, the Statue of Liberty represented more than just freedom. Due to cracks and corrosion in the iron pipes running beneath her, she stood for a towering repair cost. But by using an innovation called Driscopipe,® created by Phillips Petroleum, replacing the existing pipes was unnecessary. And a job estimated at $17 million was reduced to $600,000.

You see, while the Statue of Liberty stands for the promise of a better way of life, ideas like Driscopipe help that dream come true by letting communities put their money to better use. To us, that's what it means to be The Performance Company.

She's made of iron, steel and copper. We saved her millions because she isn't made of money.



For more information on Phillips Driscopipe, write to: Lady Liberty, Phillips Petroleum Company, 16 D-2 Phillips Building, Bartlesville, OK 74004.

Earth Almanac

PAINTING BY CURTIS PARKER

Pollution Swap May Halve Utility Emissions

There's a new commodity on the market—air pollution. Like stock, it can be bought, sold, and auctioned. In an innovative plan, federal pollution permits may actually help electric utilities halve the more than 18 million tons of sulfur dioxide that their stacks spewed in 1980.

That goal was established by the 1990 amendments to the Clean Air Act. Rather than setting the same emissions ceiling for all companies, a more flexible permit system based on a free-market approach was devised by the Environmental Defense Fund and the Environmental Protection Agency (EPA). Each one-year permit allows the release of one ton of sulfur dioxide; most utilities emit many thousands of tons. By 1995 companies with fewer permits than pollutants vented will pay a stiff penalty.

The EPA has distributed 5.3 million emissions permits to the 110 worst polluters. Permits for all utilities will total 9.5 million by the year 2000. As some firms install scrubbers or otherwise reduce emissions, they will accumulate excess permits, which they may sell to utilities lagging behind. After its cleanup, Wisconsin Power and Light sold 25,000 permits to the Tennessee Valley Authority and Duquesne Light for an electrifying sum—more than six million dollars. Last March, 150,000 permits were auctioned for 21 million dollars at the Chicago Board of Trade.

Anyone can buy permits, which have fluctuated between $125 and $450. Some environmental groups have sought to "buy pollution" by purchasing permits and retiring them to keep tons of emissions out of the air.

For Nutria Invaders, the Fat's in the Fire

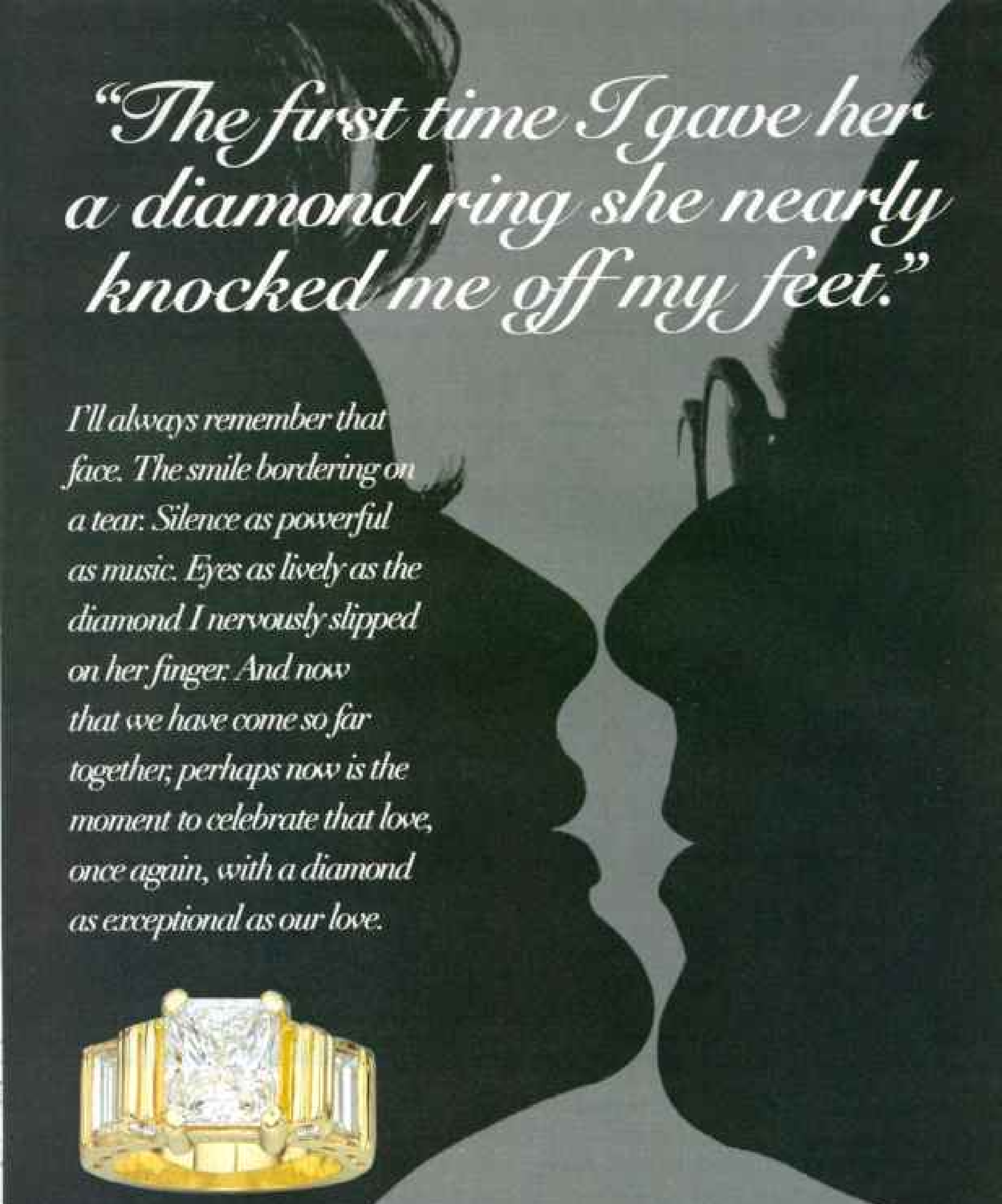
Nutria are 10- to 15-pound eating machines with teeth like scythes. Alien to the U. S., these South American rodents are now a pestilence. Introduced nutria, some of which escaped from Louisiana's Avery Island during a 1940 hurricane, have spawned a reproductive storm that has left millions from Texas to Maryland. Feeding on aquatic plants, they contribute to the yearly loss of 25 square miles of marsh in Louisiana alone.

The unwanted guests have been hunted and fed to alligators, to no avail. Trappers take few nutria because their pelts bring only a few dollars. So Paul Prudhomme, chef and owner of New Orleans' K-Paul's restaurant, proposes a creative solution: nutria cuisine. As part of an awareness campaign last summer, Prudhomme whipped up some ecologically helpful dishes—nutria étouffée, nutria sausage, nutria gumbo, and deep-fried nutria.

"The taste and texture is a lot like the turtle meat we eat down here in Louisiana," Prudhomme says.

MYOCASTOR COYPUS BY E. C. LOCKWOOD, BRUCE COLEMAN

National Geographic, December 1993


"The first time I gave her a diamond ring she nearly knocked me off my feet."
I'll always remember that face. The smile bordering on a tear. Silence as powerful as music. Eyes as lively as the diamond I nervously slipped on her finger. And now that we have come so far together, perhaps now is the moment to celebrate that love, once again, with a diamond as exceptional as our love.
Exceptional woman.
Exceptional diamond.
An exceptional diamond of two carats, or more, is so rare that fewer than one percent of women will ever own one. If you are considering an important diamond gift for your wife, like this ring featuring a brilliantly cut 3.21-carat center stone, simply call for your guide to a diamond's quality and value, as well as the name of your local expert diamond jeweler. 1-800-2JEWELS
De Beers
A diamond is forever.

School principal Pete Carey has good reason to believe that NUCLEAR ENERGY IS GOOD FOR THE *air* (and the kids).

His elementary school sits five miles from a nuclear power plant near the Michigan-Ohio border. And after telling you about his daughter's fast-pitch softball team, Pete Carey is happy to tell you what he thinks of nuclear energy.

"The biggest benefit is environmental. It's efficient and it doesn't pollute the air."

There are more than 100 nuclear plants in the U.S. Because they don't burn anything to make electricity, they help protect our environment and preserve our natural resources. For Mr. Carey's schoolchildren, and their children too. All while providing enough electricity for 65 million homes.

No single energy source can be the whole answer to all of America's energy needs. But, as Pete Carey will tell you, nuclear energy is part of the answer.

For more information, write to the U.S. Council for Energy Awareness, P.O. Box 66080, Dept. C, Washington, D.C. 20035.

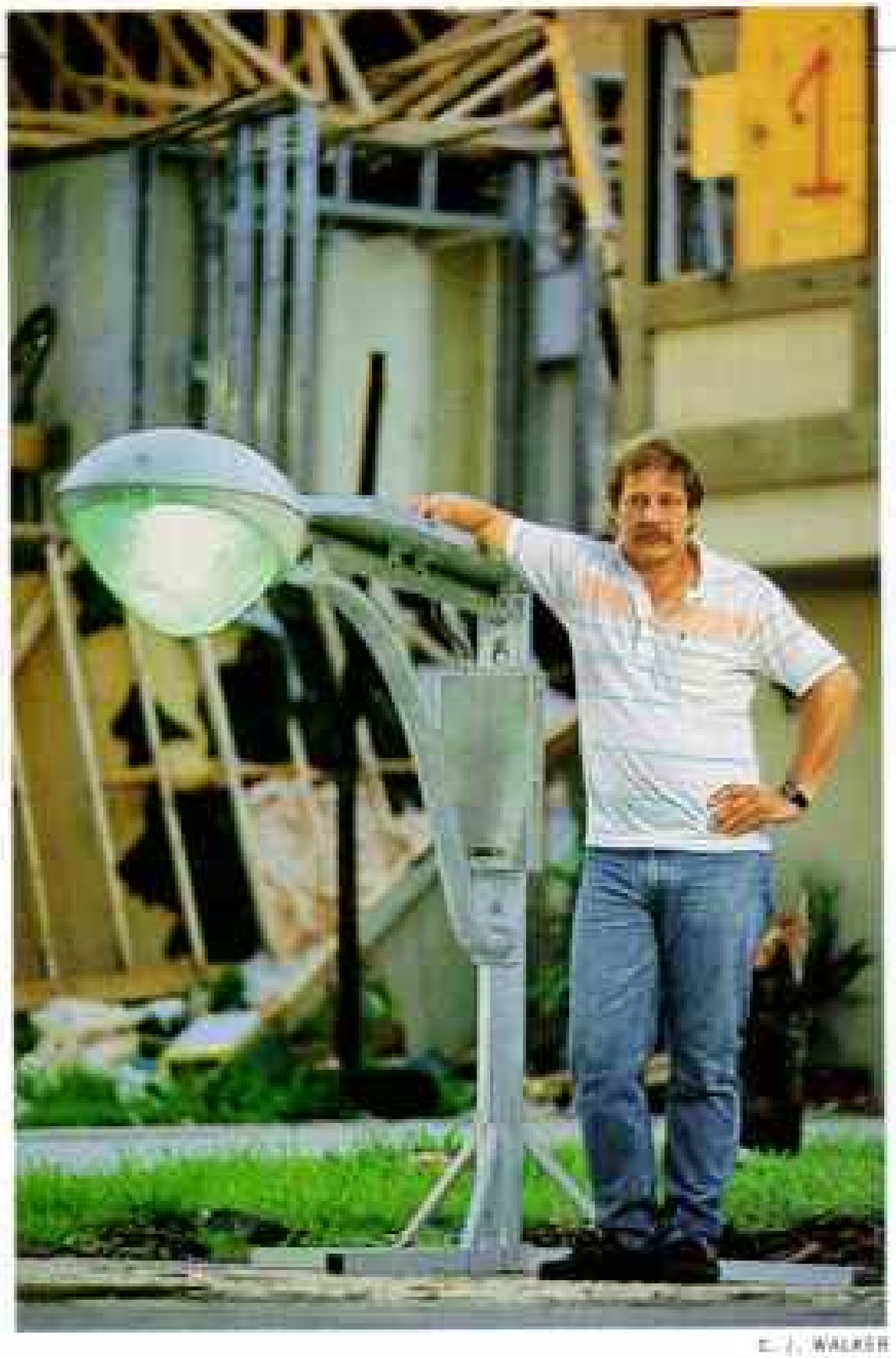
NUCLEAR ENERGY MEANS CLEANER AIR

Earth Almanac

Sun Power Brings Disaster Relief

Refugees cursed the darkness after Hurricane Andrew's devastating winds snuffed out South Florida's electricity on August 24, 1992. But Steve Robbins (right) of Solar Outdoor Lighting lit a candle with his invention, a solar-powered streetlight. After the storm, five of them lit entrances to medical clinics and relief centers selected by the University of Miami's Field Epidemiology Survey Team (FEST).

"It was pitch-black, and trees were down everywhere. It was tough to find your way around without these lights," said David Taplin, head of FEST. Computer-controlled and powered by a solar panel that charges a battery, they proved popular in hard-hit Kendall, where people played cards beneath them.



C. J. WALKER

FEST also used solar-powered filtration units to purify drinking water and three solar refrigerators to preserve vaccines. Clinics without refrigeration lost thousands of dollars' worth of medicine.

MERGUS APIASTER BY CLAUDE BARANGER

Bee-eaters: Lovely Shades of Death for Insect Fliers

Bill filled with a fat cicada, a European bee-eater has snared its meal in midair. Feathered fighter pilots, these birds can spot insects a hundred yards away and, like cruise missiles, follow their evasive maneuvers to the kill. Two dozen bee-eater species range from Europe and Africa to Asia and Australia. They are as gaudy as macaws; one species is called the rainbow bird.

But cicadas are easier prey than what bee-eaters tackle more often—bees, wasps, and ants. How do the birds avoid the stings and venom?

"When a bee-eater catches a venomous insect, it perches and hammers it on a branch to kill it," says Peter Wrege of Cornell University, who has long studied bee-eaters with colleague Stephen Emlen. "Then it shifts the insect around in its bill and squeezes the abdomen while scraping it against the branch. The stinger often comes out along with the venom. It's very elaborate behavior."

Horse of a Different Color Is Vanishing

Promoted as "hippotigris" by Emperor Caracalla, who displayed this gift from Africa in the Colosseum around A.D. 200, the species known today as Grevy's zebra is endangered. Its numbers, 15,000 strong in the 1960s, have dwindled to perhaps 5,000, all in southern Ethiopia and northern Kenya, where these stallions spar in Buffalo Springs National Reserve.

Related more closely to horses than to other zebras, Grevy's are distinguished by narrow stripes. The species was heavily hunted for skins to make purses before 1976, when Kenya passed protection laws. Now pressures have arisen from herdsmen and their livestock, which compete with the zebras for water. As a result mares raise fewer foals, researchers suspect.

—John L. Eliot

EQUUS GREVYI BY STAN OSOLINSKI, DEMBINSKY PHOTO ASSOCIATES

Should a personal computer be the big gift this year?

Is there a gift that can make more of a difference in the lives of your family than a personal computer?

A personal computer can be a business center or an entertainment center. It can help your kids with work from school and you with work from the office. It can keep finances in order and report cards in order.

There's only one catch: you have to learn how to use it first.

Now, with an ordinary PC, this is a fairly serious drawback. But with an Apple® Macintosh® Performa,™ it's no trouble at all. Because Performa was designed to be the family computer: easy to set up, easy to learn, easy to use. And now, easier than ever to afford.

It's a gift for kids.

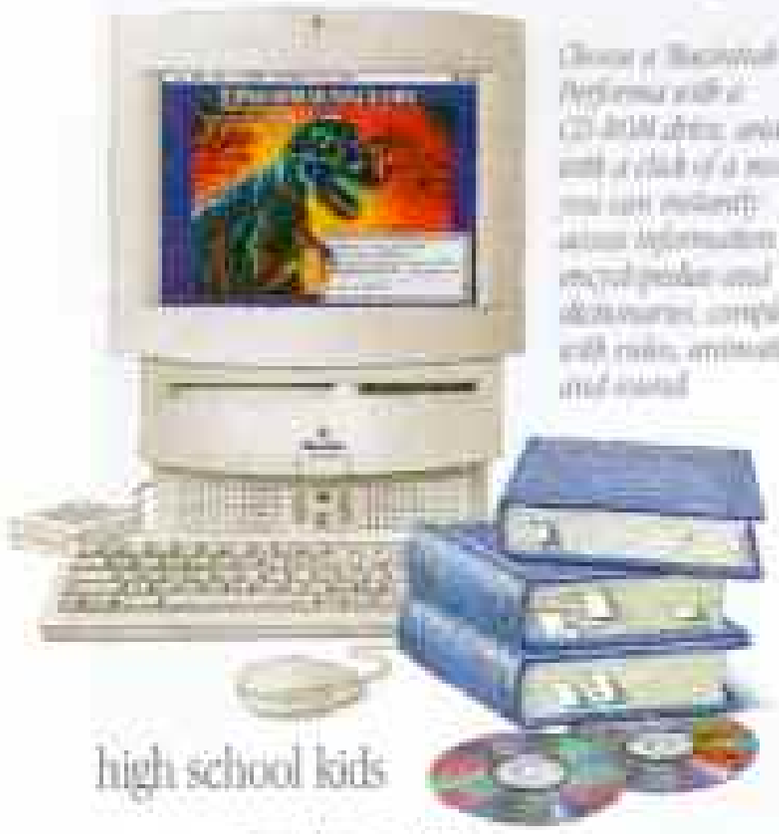
If you have kids in school, the odds are they're already using an Apple computer. Because more schools use Apple than any other brand of computer.

A Macintosh Performa comes with the most popular software already installed. So right out of the box, your kids can start working with the

Apple Macintosh Performa

word processing software to make their homework more polished, and with the graphics software to help them explain their ideas more clearly.

Every Performa can run hundreds of captivating Macintosh education programs that make learning more involving and fun—to help kindergartners learn how to read and write, or help



Choose a Macintosh Performa with a CD-ROM drive, and with a click of a mouse you can instantly access information in encyclopedias and dictionaries, complete with video, animation and sound.

high school kids prepare for their SATs.

And with its built-in stereo sound and brilliant graphics, a Performa running entertainment software makes ordinary video games look like, well, kid stuff.

It's a gift for parents.

The magic of a personal computer is that you can change what it does simply by changing the software.

You can turn the same computer from a science lab into an artist's palette into a powerful financial management tool.

Every Performa comes with business productivity software already installed: a spreadsheet, word processor, customizable database and more.

It also works with information from a standard business PC as well as from a Macintosh, so you can bring your work home from the office.

Finally, Performa brings the point-and-click simplicity of a Macintosh to a wide range of software for managing your family finances—programs that help you do your taxes, plan your retirement, track investments and balance your checkbook.

It's a gift that comes already assembled.

You can set up a Performa in a matter of minutes. Powerful productivity software is already installed. So is a program called At Ease™ that makes it easy for even young children to work with a Performa.

Just plug the keyboard and monitor into the computer, and the computer into the wall, and you're ready to go.

There's no system to configure. No AUTOEXEC.BAT or other complex codes that other PCs demand you learn. It's all simple, logical and practical.

It's a gift you can afford.

The price of personal computers has fallen dramatically over the past year. So

Every Performa comes equipped with many features you may pay extra for with other computers. Such as a fax/modem and all the software your family is likely to need. And to name a few.

you'll be surprised how affordable a Performa can be.

And Performa is an even better value when you consider everything that comes with it: all the software your family is likely to need; a fax/modem that lets you

A Macintosh Performa can't simplify the last couple, but it can make doing your income taxes, balancing your checkbook and managing your family finances easier than ever.

send a fax directly from your desk to a fax machine (or connect, via telephone, to services like America Online and Prodigy); unlimited toll-free telephone support (even with the easiest computer, you may have questions once in a while); plus a year of in-home service* (in the unlikely event you should need it).

The whole idea is to make owning a computer an incredibly satisfying experience. To find out just how easy it actually can be, give us a call at 800-538-9696, ext. 215.

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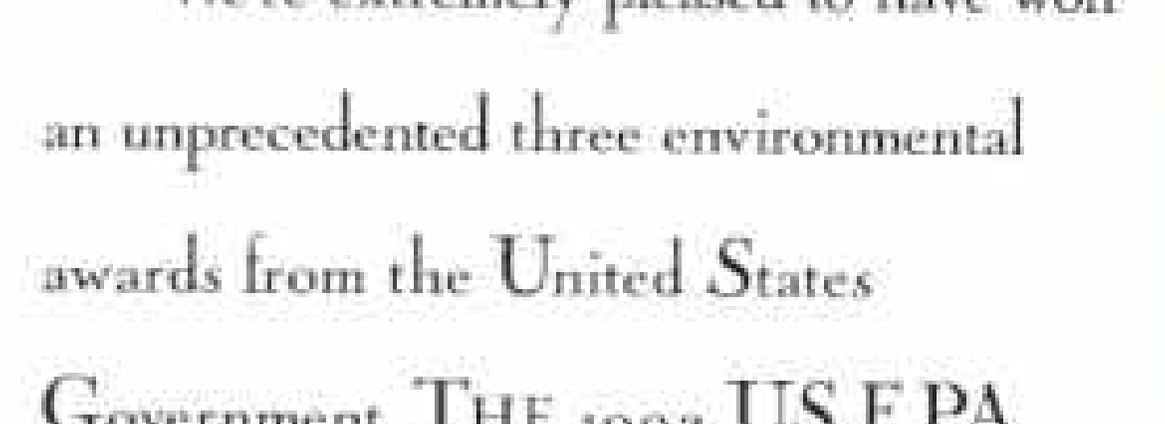
Performa

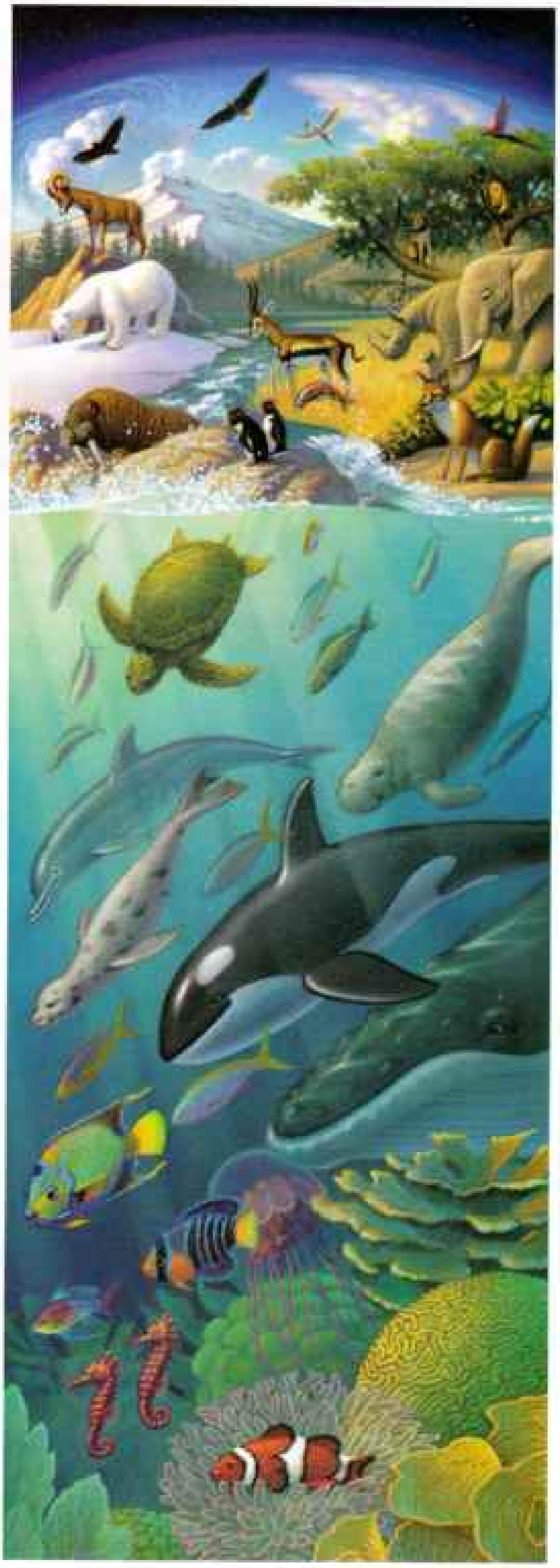
The Family Macintosh

OF ALL THE AWARDS WE WON LAST YEAR, THESE MAY MEAN THE MOST.

As automotive awards go, last year was a banner year for the Chrysler Corporation. Among them were several awards of special importance, not only to us, but to other residents of this world as well.

We're extremely pleased to have won an unprecedented three environmental awards from the United States Government. THE 1992 US EPA STRATOSPHERIC OZONE PROTECTION AWARD. THE 1992 PRESIDENT'S ENVIRONMENT &





CONSERVATION CHALLENGE AWARD and THE 1992 US EPA ADMINISTRATOR'S AWARD. It's not easy to produce a reliable, economical vehicle while being sensitive to its environmental impact. But we're doing it. And we're getting better at it all the time.

Here are some of the achievements that helped us earn these awards: As early as the 1980s we began reducing emissions from our painting operations. Improved paint application lowered plant emissions by 70% and we discovered how to create a high quality finish while using 50% less paint.

We have also taken aggressive action to help preserve the fragile ozone layer. By 1994, all new Chrysler-built products will have CFC-free air conditioning units. That puts us years ahead of worldwide guidelines.

What about recycling? It makes as much sense for our plants as it does for our homes. Each year we recycle more than 26,000 tons of cardboard, 35,000 tons of wooden pallets and over 700,000 tons of scrap metal. Even better, newly implemented programs aim to eliminate 95% of all packaging wastes.

With all this talk about reduction, there are a few things we're proud to say we've expanded on. One of these is alternative fuel technology. Chrysler Corporation already has electric, natural gas and methanol fuel vehicles for sale today. Which also puts us ahead of government guidelines.

While we're proud of our achievements so far, there's still room for improvement.

We'll keep working for a day when the only by-products from our plants are more of these awards.

After all, the whole world is watching.

CHRYSLER CORPORATION

Fergie on a rock

by

Ann Crump, painter

The Nikon N6006 is a serious SLR that almost anyone, anywhere can pick up anytime and have fun with.

Case in point, one Ann Crump, watercolorist and oil painter from Belvedere, California.

In other words, she's not a professional photographer.

Yet, using the N6006 and a 28mm Autofocus Nikkor lens, she and her three-year-old pug Fergie have created nothing short of a masterpiece.

Or at least one killer dog picture.

The N6006 is why. It focuses automatically in light as dim as a single candle, or you can focus manually.

It selects the proper exposure automatically, or lets you do it.

You can select from a Spot Meter, a Center-Weighted Meter, or the Nikon Matrix Meter, which reacts instantly when the action is moving fast or the light changes unexpectedly.

Here, the built-in flash automatically brightened the foreground while letting the sun shine through in the background.

Maybe you thought a picture like that was too difficult.

Well, Ann Crump did it with just one hand, while holding a dog biscuit over her head.

Quite a picture in itself.

The Nikon N6006 is controlled by a convenient dial and a simple multi-button keypad. An LCD readout clearly shows you what you're doing. Press any two buttons on the keypad and the camera reverts to totally automatic.

It forgives you, instantly.

With Focus Tracking, the N6006 can even keep moving subjects, such as cars or bikes, in focus.

Its motor advances the film fast and rewinds automatically.

You can choose from twenty interchangeable autofocus Nikkor lenses. Nearly seven out of ten pros who use 35mm use Nikkor lenses.

In other words, the N6006 is not a toy.

It's the camera designed for people with dogs to walk, kids to chase and a job to go to.

And somewhere in between all that, pictures to make.

Well, with the N6006, it's not any harder to use a Nikon. It's not any harder to take the kind of pictures you've always dreamed of instead of just plain old pictures.

After all, the shot above was made by an ordinary person using an extraordinary camera.

Could it *possibly* be more beautiful?

See the N6006 at authorized Nikon Dealers. But look for this symbol. For more about the N6006, and the benefits of the exclusive Nikon MasterCard, call 1-800-NIKON-35.

Nikon

Eruption of Kilauea volcano on Hawaii

"When you're working on a volcano, your equipment and wits can't fail you."

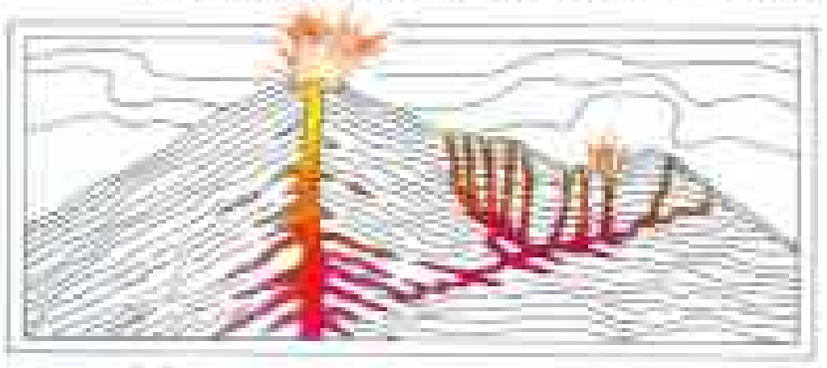
—Dr. Michael Garcia

Earthquakes rock the black, rippled terrain. Fire fountains explode from the mountain's side. Iridescent orange lava, as hot as 2100° F, sweeps down the volcano's flanks in thin sheets and swift rivers. The air is filled with the roar of molten rock slamming against a crater wall. It rains pumice.

Dr. Michael Garcia

This is Kilauea, which ascends majestically from the floor of the Pacific and disgorges a continuous stream of lava that can fill a large stadium in less than a day. Professor Michael Garcia has devoted his career to exploring the mysteries of volcanoes, particularly Kilauea, one of the most active in the world. "It's the premier place to study how volcanoes work," he said.

Dr. Garcia has been gathering data on Kilauea since 1978. When he is not in the lab conducting chemical analyses of lava, Garcia is in the field, measuring intervals between fire-fountain pulses and plucking samples from lava rivers. He believes that a keener understanding of the volcano and its internal



Magma conduits inside Kilauea

structure can help scientists better anticipate eruptions.

Working in such a hostile environment, Garcia must rely on his experience, instinct and equipment. "You have to respect Kilauea's might—especially when you feel it rumbling beneath your feet," he said. Demanding the highest standards from his instruments, Dr. Garcia insists that they be rugged and reliable.

It's little wonder that he has chosen a Rolex Oyster Perpetual as his timepiece.

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On Assignment

ERIC VALLI

Dangling from jagged cliffs with Nepalese honey hunters or climbing through torch-lit caves for birds' nests in Thailand, photographer Eric Valli, at right, and writer Diane Summers get their stories for NATIONAL GEOGRAPHIC in hard-to-reach places. They do it by living with the local people, often for months at a time. With their children, four-year-old Sara and two-year-old Camille, the couple traveled with villagers of Nepal's northwestern reaches to report on the salt traders of the Himalaya. Following caravans of yak or sheep, the family trekked some of the highest mountain passes in the world.

Here sheepskin coats and camaraderie warm Eric and his friends before the departure of a yak caravan. Lakpa Gyalzen Sherpa, at left, served as assistant and interpreter, as he had for coverage of the honey hunters of Nepal for the November 1988 GEOGRAPHIC and a subsequent book. Doctor of traditional medicine and headman of the village of Saldang, Tundup, center, tutored Eric and Diane in the Tibetan way of life, which survives in Nepal's Dolpo region.

Eric first visited Dolpo in 1981, three years before his chance encounter with Diane, an Australian lawyer on holiday, on a rickety bus in Nepal. The two determined to make a living out of their mutual love of adventure; now their young family calls Kathmandu home. Sara and Camille speak their father's French and mother's English fluently, "but Nepali is probably their first language," says Eric.

Immersion in the culture is key to Eric and Diane's reporting: they invest years in getting to know their subjects. "We care about these people," Eric says. "Wherever we go, we try to learn the language. Diane and I read, we listen, we talk to the people, we explore, and that's how we come up with story ideas." The couple are now writing a book, their fifth, about the Himalayan caravans and also plan a film.

Documenting Asia's threatened traditional cultures has become their mission. "It's our duty to record these ways of life before they disappear," says Eric. "When you go to new places, you learn that others have a completely different way of looking at things. The Himalaya, for example—we imagined it to be this huge barrier. But the caravans prove that the mountains have always been a passageway."

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Geoguide

BOTH BY WILFORD TAYLOR

Lake Superior

• In size Lake Superior is more like an ocean than a lake. If you paddled a kayak along Superior's 1,700-mile shoreline—making 20 miles every day—it would take you roughly three months to go all the way around. Do you think it would be possible to paddle across the lake? What are some of the dangers a paddler would face?

• Why does Superior have more wilderness left around its shores than any other Great Lake?

• Isle Royale, an island wilderness of forest and wetlands in the western half of Lake Superior, has no roads and no cars (map, page 77). About 45 years ago wolves arrived on Isle Royale. How do you think they got to the island—15 miles from shore? For a clue see the photograph on pages 86-7.

• In the 19th century many people came to the Lake Superior region from areas of Europe mentioned on pages 84 and 91. What natural resources attracted the immigrants? Today relatively few people are moving into the region despite its great beauty. Why?

• The name of the character Winnie-the-Pooh was inspired by a black bear cub called Winnie, from White River, Ontario. On a map of Canada find the town of White River, near the eastern shore of Lake Superior. In which direction would you travel to go from White River to the big city for which the cub was named? That city is the capital of which province?

LAKE SUPERIOR OFFERS BOTH JOBS AND RECREATION NEAR BAYFIELD, WISCONSIN. EAGER GULLS AWAIT SCRAPS FROM FISHERMAN MARTY ERICKSON'S CATCH (ABOVE). GAIL GREEN (LEFT) GUIDES KAYAKERS ON AN EXPEDITION.

USE THE GEOGUIDE PAGE ALONG WITH THE ARTICLE "THE SUPERIOR WAY OF LIFE" IN THIS ISSUE TO HELP CAPTURE THE INTEREST OF YOUNG READERS AND STIMULATE DISCUSSION WITH THEM. GEOGUIDE IS PUBLISHED FOUR TIMES A YEAR.

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