THE MAKING OF AMERICA: GREAT LAKES

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ONE SUNDAY MORNING I watched as a television program rhapsodized over the quiet beauty of Big Moose Lake in the Adirondacks of New York. The well-meaning interlude lulled viewers with romantic scenes, soft music, and words describing the lake's serene quiet and crystalline waters.

It was like interrupting a death vigil at a hopeless bedside. The lake was quiet, too quiet—no trout jumped, no ospreys dived to disturb the lovely north-woods tranquillity. Sadly, Big Moose was virtually devoid of any living thing, doomed by man-made chemicals that fall into it with every acidic rain.

Looks can be deceiving—especially if we want to be deceived. This month we take an unromantic look at five great lakes—*the* Great Lakes. Some of you will feel that we should find our rose-colored glasses and take another look—that we have looked past their grandeur, their beauty, their dynamic economic value and found only the sordid and the bad news. You may feel that we have been deceived.

True, the lakes are not dead yet. Lake Erie, a candidate for obituary notices by the late 1960s, is now clearer and in some ways cleaner: Inputs of raw sewage and phosphates have been greatly reduced. Yet held in its sparkling waters—and in the other lakes as well—is a witches' brew of chemicals that may be even deadlier. And now in an unrelated phenomenon the lakes almost seem to be exacting some primal revenge against their human polluters.

A natural rise in lake levels is wreaking havoc with man's proud constructions on the banks. Slow erosion and roaring, ocean-like waves nibble the shore or devour it in great gulps, combining to destroy hard-earned lakeside homes and make miles of valuable shore dangerous and even unusable.

These lakes—collectively the world's largest body of fresh water—are not so much a border between Canada and the United States as they are a link. Wonderful assets to both nations, and home and haven to thousands of Indians long before Samuel de Champlain led Europeans to their shores, the lakes now need—and have begun to receive—both nations' united, thoughtful, unromantic attention.

Staff writer Charles Cobb and ten photographers have given the lakes thoughtful attention and bring you the concerns of the people—laymen and scientists alike—who live along and work to improve these Great Lakes.

Wilbur E. Garrett

EDITOR

NATIONAL GEOGRAPHIC

JULY 1987

COVER: *A Japanese novice geisha delicately eats a morsel of slippery tofu, a prized product of the soybean. Photograph by Chris Johns.*

THE NATIONAL GEOGRAPHIC MAGAZINE
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THE GREAT LAKES'

Filled to the brim, North America's freshwater seas are at the clearer, but unseen toxic chemicals continue to poison their

By CHARLES E. COBB, JR.
NATIONAL GEOGRAPHIC EDITORIAL STAFF

APARTMENTS ON CHICAGO'S NORTH SHORE ARE BESIEGED BY WAVES DURING A STORM LAST FEBRUARY. PHOTO BY FRED JEWELL, ASSOCIATED PRESS

TROUBLED WATERS

highest levels in a century. After years of effort the lakes are waters, troubling the 40 million people who live near their shores.

Photographs by BOB SACHA and RICHARD OLSENIUS

SOMETIMES WAVES slam the shoreline of Lake Erie hard enough to rattle the dishes inside Bob Rumes's china cabinet. Bob wishes that a few cracked plates were his only worry, but the lake, here at Willoughby, Ohio, seems determined to take his entire yard. In 1950 it sloped down some 160 feet to a sweeping beach. Since then 60 feet of his lot have been swallowed by the lake—20 feet last year alone. And now there is no beach at all.

I stood with him at the edge of his property. It ends abruptly where a broken wall slides down a jagged escarpment.

"With the beach gone, we take a terrible pounding from waves hammering solid bank," he told me. Helplessness and sadness hung in the air, and a little anger. "This has been going on for three years. It's bad!"

Some of his neighbors have fled. Their houses perch precariously at the water's edge. In one home the living room extends dizzily over Lake Erie; in another, the garage. Eight houses have been condemned.

Simply stated, the Great Lakes are filled to the brim. Four of them—Superior, Michigan, Huron, and Erie—recently reached their highest recorded levels in this century; Ontario was close behind. In many places their shorelines resembled battlefields.

The analogy to war is uncomfortably apt. These life- and property-threatening lakes are, for their own part, also in a key battle for survival. And to them, *we* are the enemy.

To most of us the Great Lakes have always seemed glorious, infinite, and invulnerable. We have prospered greatly from them, but in so doing have pushed them to the limits of good health. And perhaps it is not farfetched to say that with the pressures of our population, our industry, and even our recreation, we have pushed them to the limits of their patience. We realize that there is a price for what we have demanded of them—and the price tag is going up.

Environmental pollution is a national and global problem, but long abuse has inflated the toll to the Great Lakes. For decades we have buried chemical waste along their shores and poured sewage and fertilizer runoff into their waters. Is it any wonder that they are hurting, that we, bound as we are to the lake system, are threatened in return?

According to a 1985 study conducted by the Royal Society of Canada and the U. S. National Research Council, the 40 million people living in the Great Lakes region are exposed to more toxic chemicals than those in any comparable segment of North America. "We can't define the [human] risk," Dr. Jennifer Ellenton, who worked on the study, told reporters, but "we are a part of the Great Lakes ecosystem, and the system is contaminated."

Ecosystem was a word I heard often while traveling and questioning the future of the lakes. Dr. Jack Vallentyne, a senior scientist at the Canada Centre for Inland Waters, defines his ecosystem as: "Me, plus the air, water, minerals, plants, animals, and human relationships on which I depend."

He, too, has a warning: "The basin as an ecosystem is in jeopardy; it's off balance. Just as my body has limits, so does the Great Lakes basin. We've reached those limits."

NEVERTHELESS, even as I gathered disturbing data while traveling from one end of the lakes to the other—a span of more than 800 miles—I found it hard to believe these enormous bodies of water could be endangered. Rarely was I anything less than awed by them. For in truth, these are inland seas: "Sweetwater seas," 17th-century French Jesuits called them.

The smallest in area, Ontario, is 53 miles across and 193 miles long. All told the lakes cover almost 95,000 square miles; together they hold some six quadrillion gallons of fresh water. That is one-fifth of all the surface fresh water on earth and 95 percent of all the surface fresh water in the United States. Pour that over the contiguous U. S. and we'd all be in water ten feet deep.

Thirteen percent of the U. S. population and 32 percent of all Canadians live around the Great Lakes. No region of North America has given us more or served us better.

Beginning with the fur trade of French explorers (who at first thought they had reached the China Sea) and continuing with timber, grain, copper, iron ore, and coal, the lakes unlocked a continent's resources. Mills, mines, and factories gave us lakeside empires of automobiles and steel and spurred great cities: Chicago, Detroit, Toronto, Buffalo, Cleveland, Milwaukee.

As much a product of the lakes as the muscular cities are the farms that lie beyond. The Great Lakes states grow 49 percent of the nation's corn. Wisconsin produces more dairy products than any other state.

Perhaps no part of the United States is so diverse and appealing. During my travels I prowled the ruggedly beautiful, rocky edges of Lake Superior, home of Indian gods, and explored vast dunes along Lake Michigan. "And you guys back East think we just have steel mills and pollution," my friend Bill Douglas remarked in Gary, Indiana, as we strolled that city's lovely lakeside park.

Bird-watchers, rock hounds, campers, boaters, and sunbathers by the millions find the Great Lakes an irresistible playground. Sportfishing alone attracts five million anglers, who pump two billion dollars into the region's economy each year.

For all this, it was transportation—cheap transportation for the grain and ore wrested from America's heartland—that defined the lakes' importance. From Superior in the west to Ontario in the east, and thence through the St. Lawrence Seaway to the Atlantic, the Great Lakes form the world's largest freshwater transportation network.

In 1986 almost 60 million tons of cargo passed through the locks of Sault Ste. Marie, connecting Lake Superior with Lake Huron. About 40 million tons passed through the St. Lawrence Seaway. Fifty-five percent of Canada's grain production crosses Thunder Bay, 200 miles north of Duluth.

Duluth lies at the far western edge of the inland ocean that is Lake Superior. Winter was already making some feints at autumn as I watched the *Nea Tyhi* ease into Duluth harbor. Four horn blasts from

"... the 40 million people living in the Great Lakes region are exposed to more toxic chemicals than those in any comparable segment of North America."

"One bullhead seemed to be looking right at me with a sort of desperate grin, its lips red and swollen with tumors."

"... the worst may still lie ahead. Parts of downtown Chicago could be engulfed by Lake Michigan."

"Do you know what's down in the lake? The roof of my house, sinks, a stove, beds."

"They find that PCBs reach even the fetus and that exposure continues during nursing. ... There have been some developmental delays."

the ship sliced through the chilly October air. The 386-foot-wide aerial-lift bridge stretching across the harbor entrance rose soundlessly, and I watched the ship ease to a berth beside the giant grain elevators of Harvest States Cooperatives. Spilled, rotting grain gave the air a whiskey smell. At my feet scattered kernels were sprouting.

Linemen scrambled anxiously to make the ship fast as her captain barked commands. Officials waited nearby. With them was Dick Pomeroy, a local reporter and sometime lineman: "It's still fascinating, no matter how long you've worked here."

Part of my own fascination: realizing that oceangoing vessels sail here; for we were in the middle of America, an amazing 2,400 miles by water from the Atlantic Ocean.

Although the ship stretched the length of two football fields, "She's not a big one," shipping agent Charles Hilleren said as we made our way across her deck, slippery with durum chaff. Wheat, already gushing out of a chute from one of the dockside elevators, formed a brown pyramid in one of the holds. "The hold will take 5,400 tons, and it's just one of six," Charles told me. "All the blood, sweat, and tears my uncle put into his 500-acre farm go into this ship in about 20 minutes."

The *Nea Tyhi* had come to take American durum wheat across the Atlantic to Algeria. Algerians favor it for the couscous that is their dietary staple.

Last year ships registered to 26 nations carried 4.5 million tons of cargo from Duluth and its sister port of Superior, Wisconsin, to countries around the world.

THE WATERWAY these vessels follow, across some of North America's oldest rock, was gouged out largely by the thrusts of Ice Age glaciers, which retreated some 10,000 years ago. Ice more than a mile thick bulldozed the landscape and withdrew, leaving five gigantic basins.

Today there are waves and surf more akin to oceans than lakes. On these huge expanses of water, even after a storm has passed, the waves continue to crash—hard enough to rattle Bob Rumes's dishes, to devour his yard. Erosion occurs everywhere. More than a few homeowners have paid a heavy *(Continued on page 14)*

***Closed for the first time** by flooding, Lake Shore Drive (**below**) is seen during the February storm when northerly winds barreled down the length of Lake Michigan, piling water up all along the southern end. Though years of high precipitation and unusual cold raised lake levels, the February flood was exacerbated by an unseasonably warm winter, depriving the lakefront of protective ice barriers. Twenty-foot waves jumped seawalls, making skating rinks of parking lots (**right**) and streets for a block or two inland. Home to a tenth of the Great Lakes' population, Chicago is particularly vulnerable to rising lake levels because of its extensive lakeside development.*

RICHARD OLSENIUS (ABOVE) AND CARL HUSAR, CHICAGO TRIBUNE

A great meeting of waters

These immense natural reservoirs share an increasingly troublesome set of problems.

ONTARIO

Thunder Bay

MINN.

CANADA

UNITED STATES

Isle Royale

LAKE SUPERIOR

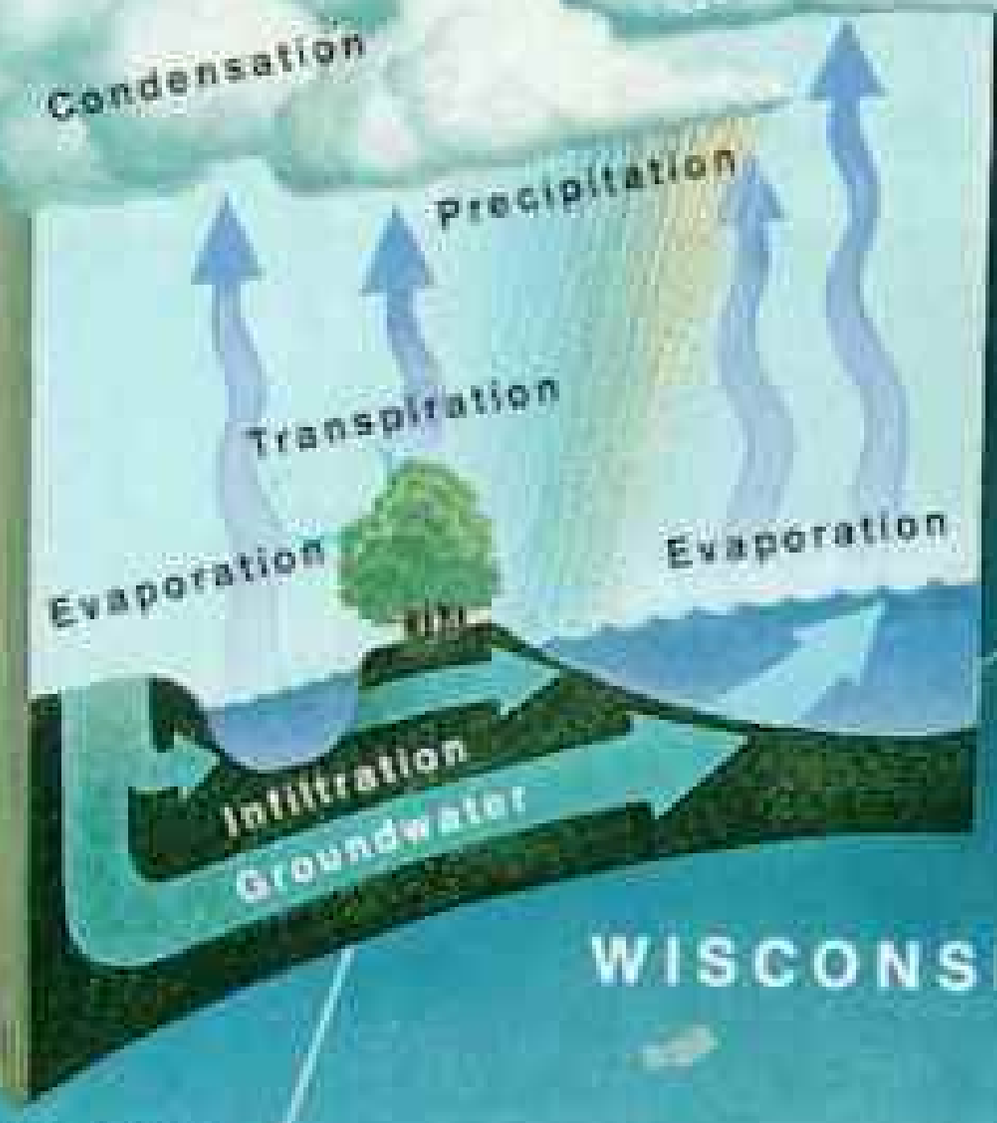
Silver Bay

Keweenaw Peninsula

Duluth

Superior

Ontonagon River



Sturgeon Bay

Fox River

Green Bay

Ludington

WISCONSIN

LAKE MICHIGAN

Milwaukee

Grand Haven

South Haven

Wind-borne toxics

Chicago

St. Joseph

Hammond

Gary

INDIANA

EVAPORATION

Of water lost from the lakes, 40 percent comes from surface evaporation. This, coupled with evaporation from the land and transpiration from plants, condenses and returns as precipitation. Periods of cold weather, as in the last two decades, decrease evapotranspiration from the land surface, reducing its capacity to absorb precipitation. Hence runoff increases, raising lake levels.

In 1985 the International Joint Commission listed 42 areas of concern, "toxic hot spots." Areas of concern are indicated by red dot.

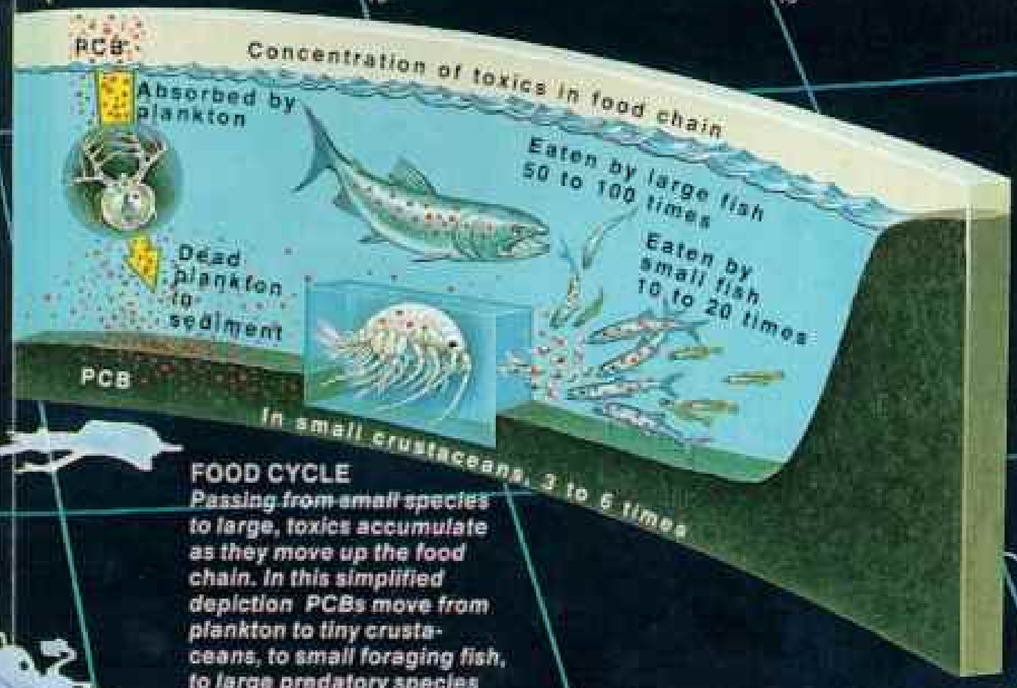
Bathymetric soundings in feet.

Illinois River

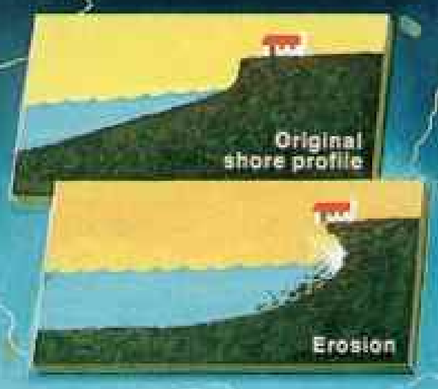
ILLINOIS

WIND-BORNE TOXICS

Fallout from fossil fuel emissions, waste incineration, and evaporation contribute volatile organic chemicals and heavy metals whose effects are only now being understood. Superior gets four-fifths of its toxics from the air, Michigan one-half.



FOOD CYCLE
Passing from small species to large, toxics accumulate as they move up the food chain. In this simplified depiction PCBs move from plankton to tiny crustaceans, to small foraging fish, to large predatory species like salmon and lake trout.



EROSION
Caused by storm-induced wave action and littoral currents, shore erosion has been accelerated by rising lake levels. Natural shoreline defenses, beaches dissipate the energy of waves to protect vulnerable bluffs and dunes. A rise of just one foot in water level can put several yards of sloping beach underwater.

SEDIMENTS & DREDGING
Lake sediments harbor microorganisms that introduce poisons to the aquatic food chain. Channels and harbors in industrial regions may contain polychlorinated biphenyls (PCBs) far in excess of allowable levels. Channel dredging stirs the sediments, recontaminating the water.

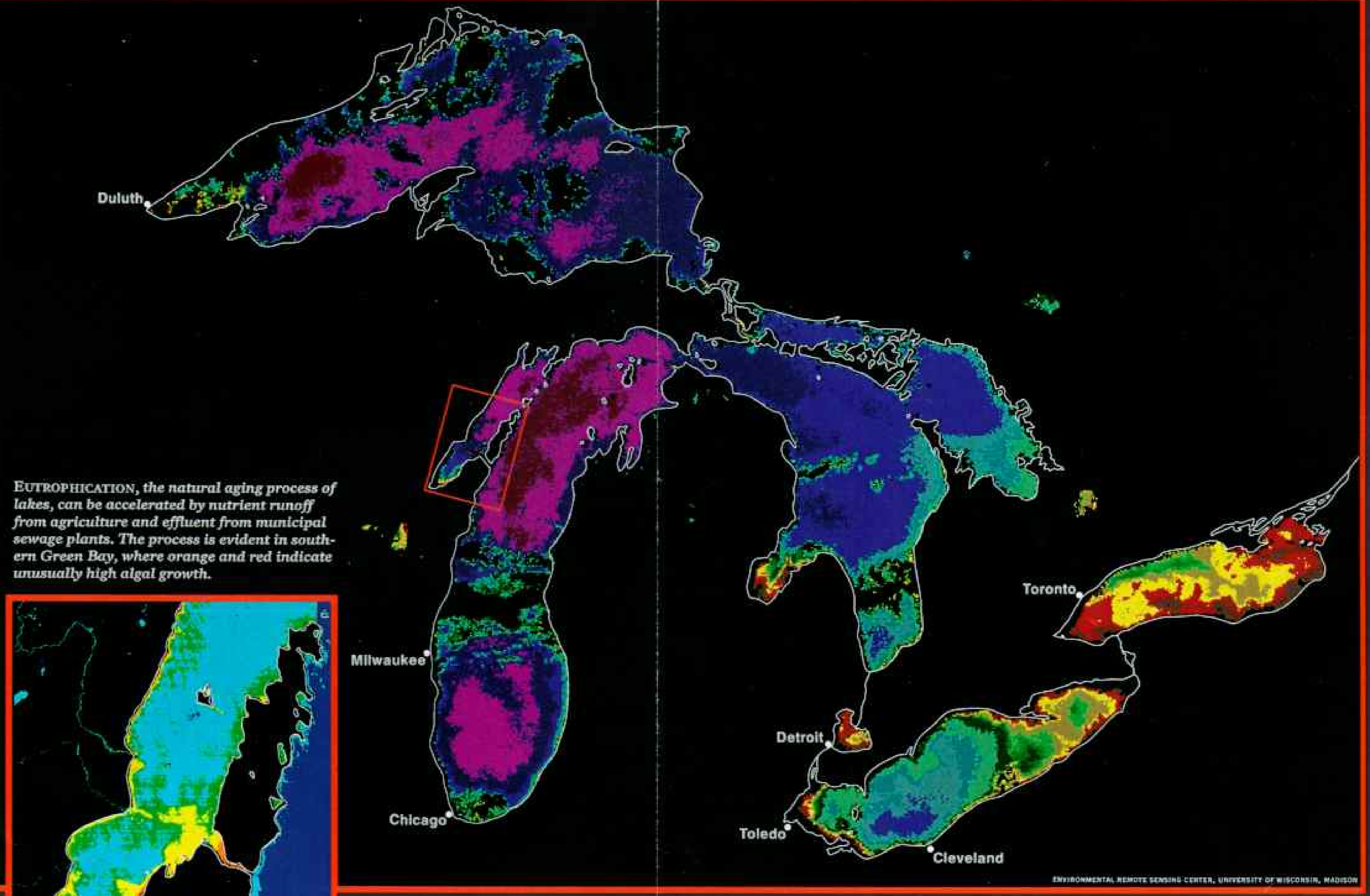
RUNOFF & LEACHING
After years of high precipitation the Great Lakes watershed is nearly saturated. Thus current rainfall runs off quickly, exacerbating current high lake levels. Leaching of pesticides and industrial toxics through subsoil remains an important route of contamination for the lakes.

MARINE INVADERS
The sea lamprey probably entered the lakes via the Erie and Welland Canals. Nearly wiping out many predatory fish species, this parasite set the stage for the proliferation of the alewife in the 1930s. By the late 1960s this species accounted for 80 percent of Lake Michigan's fish population.

WIND SETUP
Sustained wind blowing along a lake's axis piles water against the windward shore. Lasting a few hours or days, storm surges, as they are often called, are influenced by wind force, duration, and fetch, or distance the wind blows across the water.

SEICHE
A lake's surface oscillates following a disturbance, usually atmospheric. In the Great Lakes such seiches often occur after storms. In Lake Michigan rises of as much as eight feet have swamped docks and marinas, causing destruction and casualties.

PAINTING BY DAVID MELTZER
RESEARCH: HILLEL J. HOFFMAN, LINDA KRUTZ, HELEN WADSWORTH

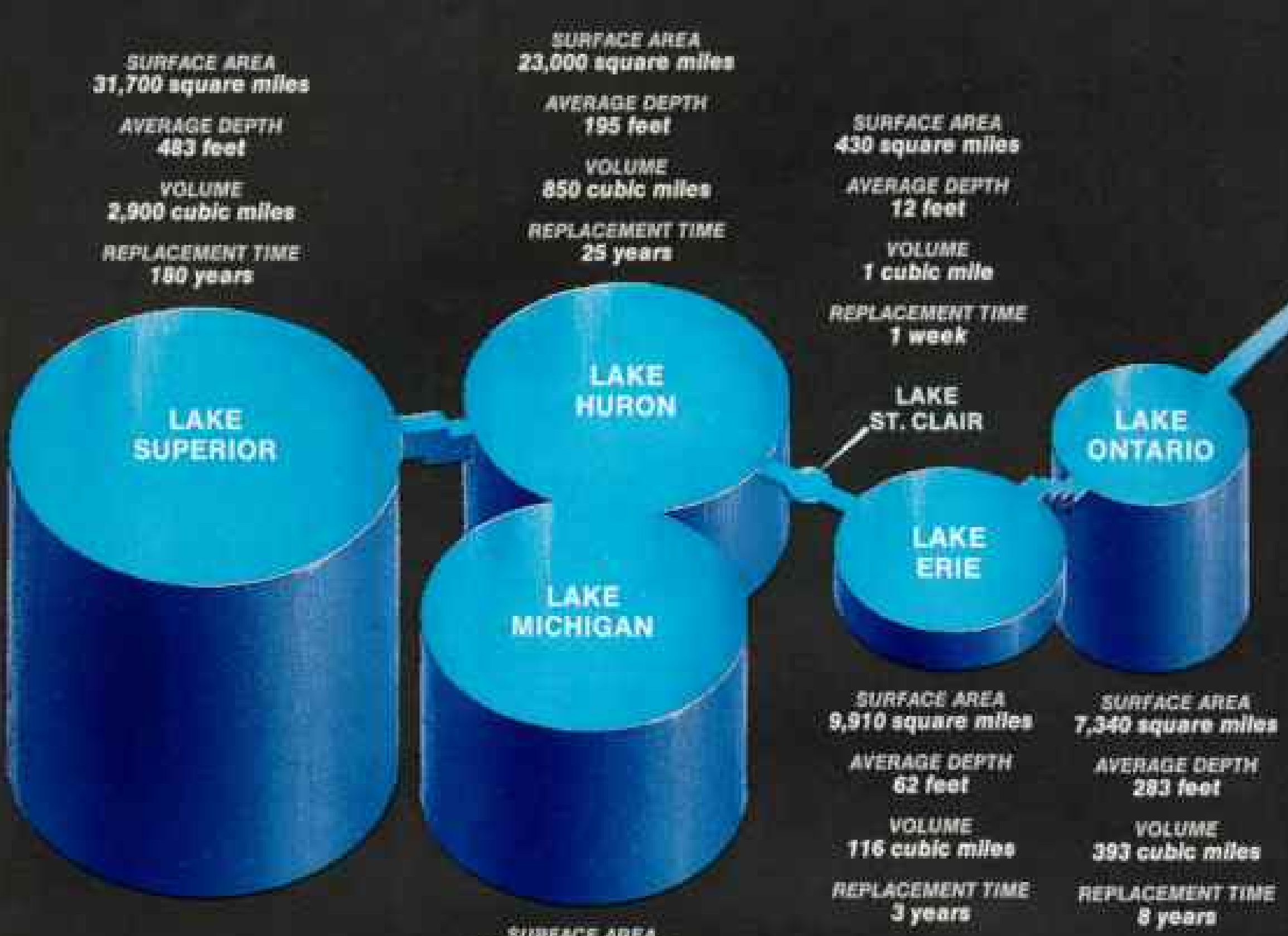


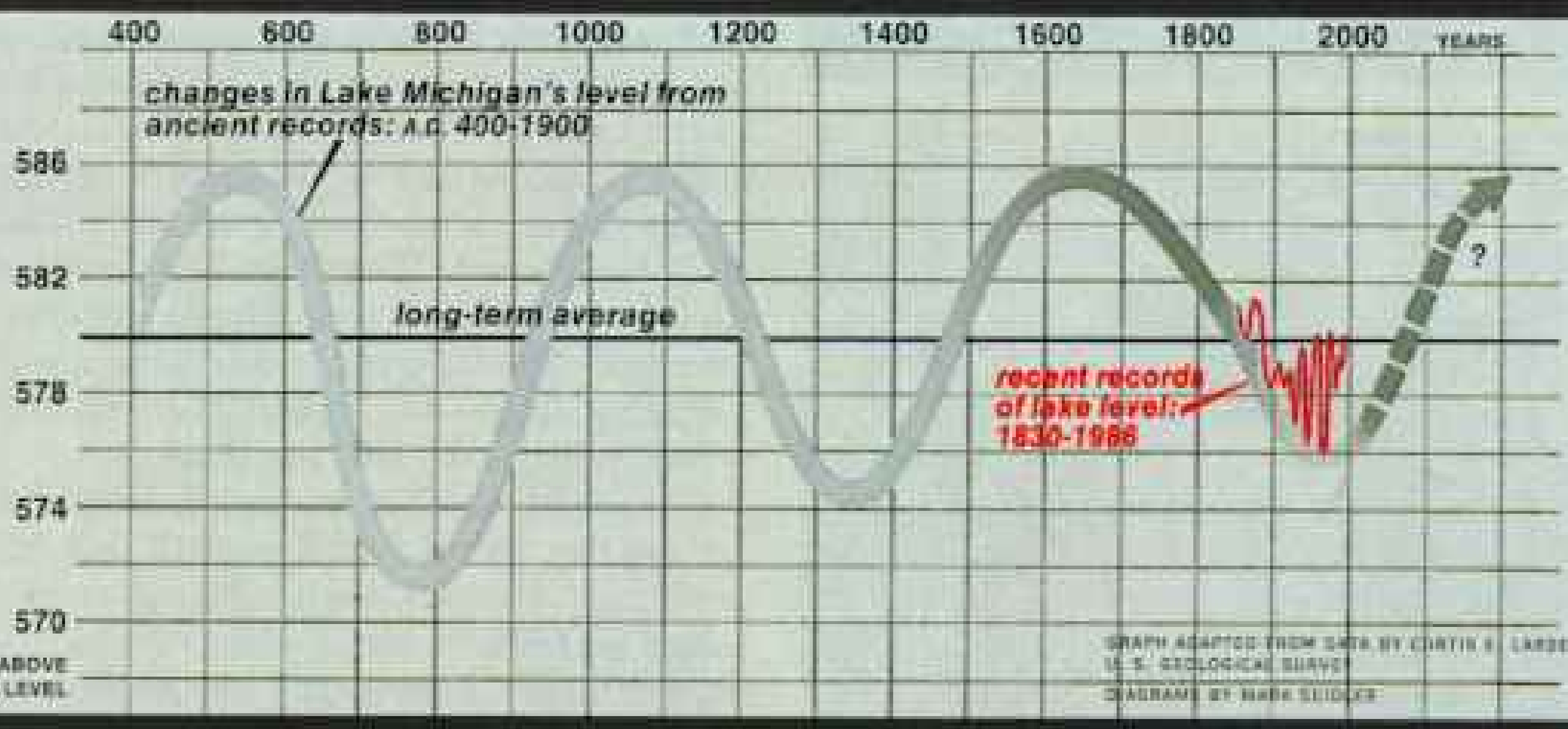
EUTROPHICATION, *the natural aging process of lakes, can be accelerated by nutrient runoff from agriculture and effluent from municipal sewage plants. The process is evident in southern Green Bay, where orange and red indicate unusually high algal growth.*

ENVIRONMENTAL REMOTE SENSING CENTER, UNIVERSITY OF WISCONSIN, MADISON

North America's fifth coast

SOME 8,000 MILES in length, the Great Lakes' coastline forms an aquatic ecosystem to rival in size and complexity the continent's Atlantic, Pacific, Gulf, and Arctic shores. Covering 95,000 square miles, the lakes contain one-fifth of all the fresh surface water on earth. Seen from a weather satellite, lake waters display a range of turbidity (above), influenced by suspended sediments, river inputs, and algal growth. (Cool colors depict low turbidity, hot colors, high.) With out-flow restricted by narrow connecting channels, the lakes form a virtually closed system. For example, it takes Lake Superior 180 years to turn over its entire volume of water. Shallow Lake Erie, with only three years' replacement time, is both easier to pollute and quicker to clean up.





CONSIDERED HIGH by modern standards, lake levels are just now approaching the long-term average for the past 1,500 years, according to geologist Curtis E. Larsen. Based on geologic and archaeological data from the shores of Lakes Michigan and Huron, Larsen calculates that lake levels have ranged between extended highs of around 585 feet and lows of 572 feet (graph above). Historical records show frequent short-term fluctuations during the most recent time of lower levels —when modern settlement around the lakes occurred. The decline reversed following the Dust Bowl years of the 1930s and, if history repeats itself, Huron and Michigan may rise an additional five feet within 100 to 200 years. But man-caused changes in the atmosphere, like the greenhouse effect, may disrupt natural processes.

Encroachment *of lake water along northern Lake St. Clair turns homes into islands for months on end. At the vacation community of North Island, Michigan, Brian Klovski's yard—dry in the summer of 1982 (***below***)—has been flooded almost continuously since the spring of 1984 (***bottom***). Across the state, at South Haven, a house teeters on a storm-eroded bluff over Lake Michigan (***facing page***). Property owners reject blame for building near the shore and lobby for projects to lower lake levels. Scientists debate the efficacy of such methods.*

D. GORTON (FACING PAGE); BRIAN KLOVSKI

(Continued from page 6)

price for the delights of lakeside living.

I drove up the eastern shore of Lake Michigan, a region under constant assault by high water. It is lined with lofty bluffs on which many homes have been built. Orchards here grow cherries, peaches, apples, pears.

In St. Joseph, Michigan, I met Donna Asselin and ached over her plight: "Do you know what's down in the lake? The roof of my house, sinks, a stove, beds. I'd never go back on the lake. I don't think people belong on the shoreline any more."

There is ample evidence to support her fears. At the eastern terminus of Lake Erie, residents of Hoover Beach, a suburb of Hamburg, New York, placed a massive revetment in front of seawalls and property. Some of the stones weighed 16 tons. Nevertheless, in 1985 a storm, pounding the shore for 24 hours, destroyed a dozen homes and forced more than a hundred families to flee.

In Michigan applications for erosion-control structures have more than tripled since 1984. In the spring of 1986 the town of Parma, New York, on Lake Ontario brought in 50 dump-truck loads of sand so residents could pile sandbags around their homes.

SANDBAGS were clearly the first line of defense in Clay Township, just north of Detroit, where lakeside lawns were soggy and swamplike when I arrived last July. Sitting on the St. Clair River, between Lake St. Clair and Lake Huron, Algonac is known as the Venice of Michigan because of its many backyard canals filled with small craft. The area faces a flood threat with every storm. Streets are often pumped. "We look like a war zone now," township supervisor Robert Wronski said when I remarked on the sandbags.

Nor are the big cities exempt. Lake waters are eroding sections of a seawall that has protected Chicago's lakefront for 50 years. I talked with Sheli Lulkin, who lives in a condominium in the northern Chicago community of Edgewater. Once beach formed her backyard. The beach has disappeared, and Lake Michigan waves crash against the buildings, sometimes splashing up to the fifth floor. Says Sheli, a condo association leader: "We are no longer on the shoreline, we *are* the shoreline."

Water levels are at their highest in 120 years, but why? I went to see Dr. Frank Quinn, head of the Lake Hydrology Group of the Great Lakes Environmental Research Laboratory. There have been climatic changes, Dr. Quinn told me. For 20 years more rain has fallen than usual. Moreover, for 25 years temperatures have been cooler than normal, slowing evaporation. And, said Dr. Quinn wryly: "You can't predict climate; it's like the stock market."

A good way to think of the lakes, he suggested, is as a series of bathtubs filling up with water from precipitation, groundwater inflow, and surface drainage from the surrounding watershed. Each bathtub, from Lake Superior to Lake Ontario, is lower than the next.

The lakes are connected by channels, but these are so narrow that the outflow of water is slow. For instance, a complete exchange of water in Lake Superior would take about 200 years.

What this means, very simply, is that when the lakes are full and there is very little evaporation, the water is not going to go anywhere anytime soon. "Everybody thinks there's a plug you can pull," sighed Dr. Quinn, "but there's not."

Adding to the problem is what is known as "isostatic rebound." The earth's crust is still rebounding from the weight of glaciers of the last ice age. Though this upward thrust is only a few inches a century, it has the effect of tilting a pan of water—downward toward the south—as the outlet channels of Lakes Michigan, Erie, and Ontario are tilted upward more rapidly than their southern shores.

There are man-made structures that modify lake levels somewhat: the Long Lac and Ogoki diversions, bringing water from Canada's James Bay watershed into Lake Superior; the Chicago diversion, removing water from Lake Michigan via the Illinois River; regulation at the St. Marys River, channeling water to Lake Huron; the Welland Canal, which diverts Lake Erie water to Lake Ontario; and regulatory works affecting Lake Ontario outflow.

But these only slightly alter lake levels. "If you doubled the Chicago diversion, the effect would be to lower Huron and Michigan by 2.5 inches," Dr. Quinn told me.

"A couple of inches is the difference between just above my nose and below my lips," Cliff Sasfy responded in LaSalle, Michigan. The sun glinted off the water of Lake Erie as Cliff, his wife, Sandra, and I talked at their home. I had seen the watermarks from flooding inside his home. Sandra remarked: "It's a little like waiting for the other shoe to drop. This lake can change so fast—a little wind, and you've got an instant flood on your hands."

INCHES DO MAKE a difference. After northeast or southwest winds blow along the lake's axis, water sometimes oscillates for days, rising from inches to feet—as much as eight feet—sending waves crashing to shore with terrible force.

Industrial sludge *containing oils, greases, and metals is pumped into settling ponds such as this one at the Rouge Steel Company plant* ***(right)*** *in Michigan. Though dumping is strictly regulated, contaminants still enter the lakes through groundwater leaching from landfills. This settling pond supplements a state-of-the-art treatment system.*

Each year millions of tons of sediments—like this red clay silt spilling into Lake Superior from Michigan's Ontonagon River ***(left)****—enter the lakes from tributary streams. Many are contaminated with agricultural chemicals and industrial wastes.*

JOHN AND ANN MAHAN (FACING PAGE); BOB SACHA

Lanky, dark haired, and unpersuaded that little can be done to lower lake levels, Cliff in 1985 helped form a Great Lakes coalition of homeowners. Their aim: to get the plug pulled to let water out, or to turn off the faucets that let it in. "If somebody's gonna nail my coffin shut and say it rained too much, they'd better be able to show me precisely how much it rained," says Cliff.

The taps Cliff wants turned off are at the Long Lac and Ogoki diversions. These pour an average 5,600 cubic feet of water a second into Lake Superior. "When they open the gates in Superior, we get it. It doesn't matter whether we've had a lot of rain or not."

He also wants increased flow through the Chicago diversion, dredging and control of the St. Clair and Detroit Rivers to lower Lakes Michigan and Huron, and release of water from Lake Erie through controls on the Niagara River. "What we need," Cliff insisted, "is a total management program for the Great Lakes."

MAN HAS MASTERED so much here, why not? My search for answers drove home the complexity of this vast integrated system.

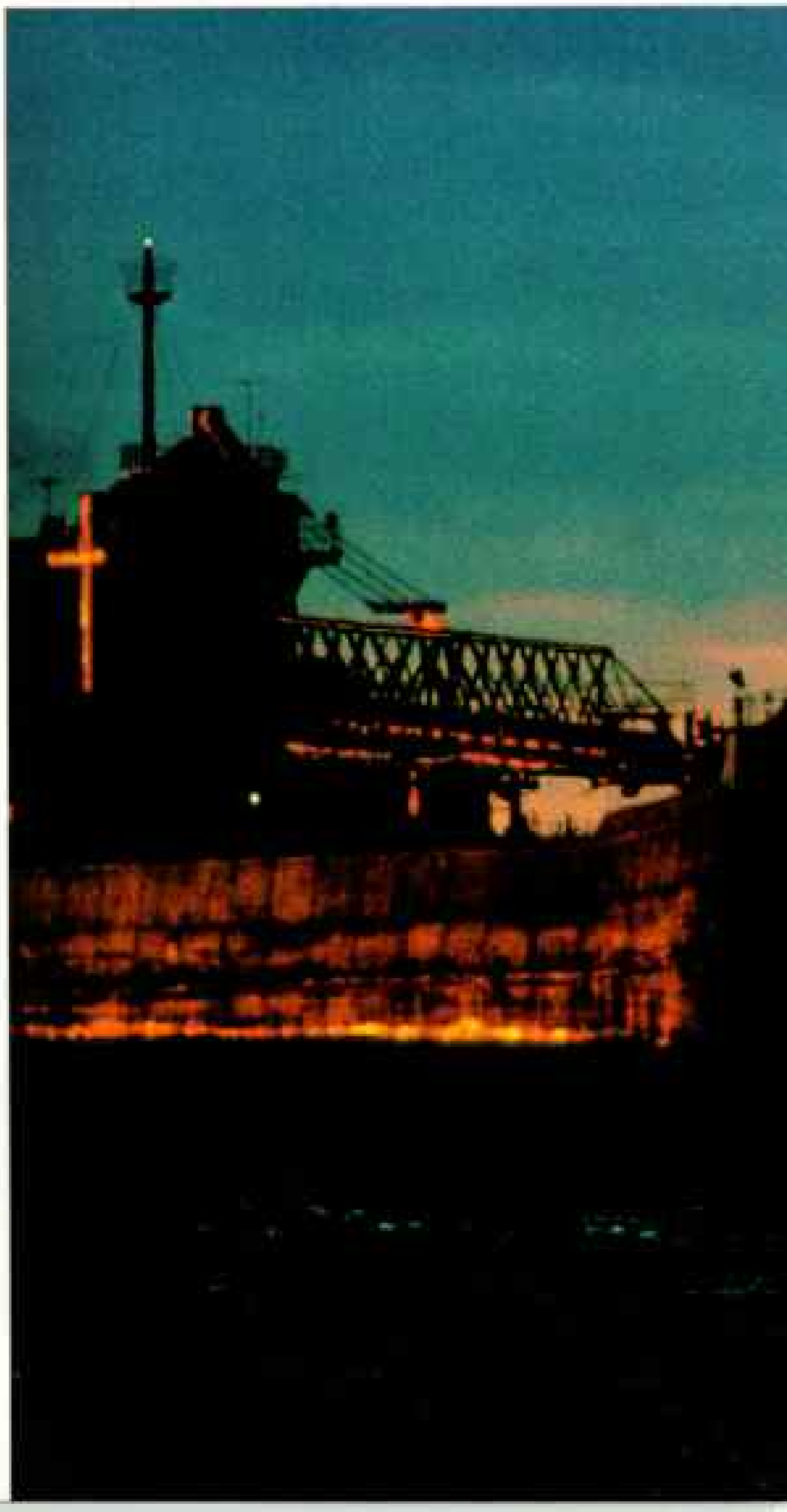
Canada and the United States share these waters. The boundary between the two nations runs right through the middle of the Great Lakes. Only Lake Michigan lies entirely within the U. S. Currently, Great Lakes policy is monitored by the IJC—the International Joint Commission—a U. S.-Canadian body created under the 1909 Boundary Waters Treaty.

According to a 1985 IJC study, changes in existing diversion flows would lower Lake Erie almost half a foot. The upper Great Lakes would drop less than a foot.

There are political considerations as well. The Ogoki and Long Lac diversions are in Canada, part of a system providing cheap and clean hydroelectric power. I met no one who thought Canada would close them permanently. And farmers in downstate Illinois, fearing floods, want no increased flow through the Chicago diversion.

Furthermore, the total management of the lakes would require massive engineering: new locks, channels, dredging. In addition to its huge cost, the environmental impact could be grave. Frank Quinn's bottom-line conclusion: "The ability of man to control lake levels is slim."

Nevertheless, pressure to do something is mounting. Dock operators complain of water seeping into grain elevators. Laws specify fines for ships that cause shore damage with their wakes, and high lake levels aggravate the problem. Last August the IJC was directed to take another look at possible control measures. It declared that "improved



Mainstay of the steel industry, *lake freighters like this vessel at Grand Haven, Michigan, provided the cheap transport for ore and coal that helped build the industrial heartland. Today there is a marked decline in smokestack industries around the lakes—home to 13 percent of all Americans and 32 percent of all Canadians.*

analytical techniques may now be available." In a November preliminary report the commission said high water levels pose the threat of a "possible emergency." It called for improving warning programs and greater coordination of flood-control efforts.

That is "directionally correct," said Cliff Sasfy, but it "only acknowledges what the Great Lakes coalition has been saying for the past year. That will be little comfort when the next storm surge strikes."

For all this, the lakes may have the final word if what some scientists are suggesting is true. Curtis Larsen of the U. S. Geological Survey has authored several papers challenging the long-held view that lake levels rise and fall within a two-foot range above and below historic averages. "That's only half the total range," he told me.

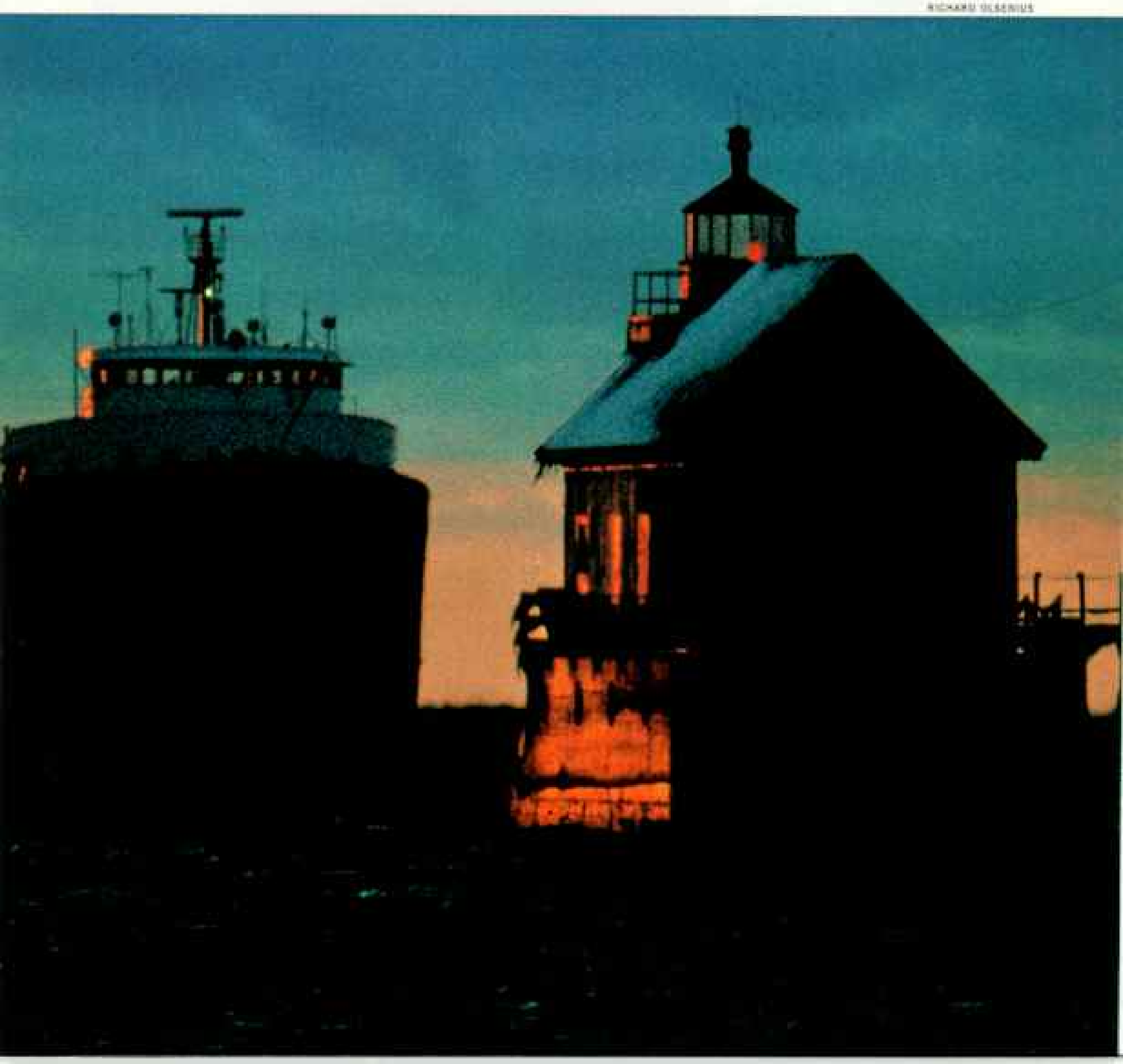
After studying sediments in the mouths of streams along Lake Michigan, as well as archaeological sites, he has concluded that for the past 100 years the lakes have been at a long-term low and are now returning to more normal levels, perhaps five feet higher. "The trend is upward," he told me, stressing, "I'm talking of centuries."

If Larsen is correct, the worst may still lie ahead. Parts of downtown Chicago could be engulfed by Lake Michigan. Sections of other cities would have to be abandoned.

PONDERING the implications of this as I traveled, I could not help but think that perhaps the lakes are exacting a sort of revenge. If they could speak about how we've misused them, I suspect we'd hear a little pain in their voices. It did not take us long to wound these waters.

In 1866 Charles W. Penny, a Detroit

RICHARD OLSENIUS



RICHARD OLSENIUS (ABOVE) AND BOB SACHA

Some 2,000 miles from the ocean, *Chinese merchant seamen scrape December ice off their grain freighter at Canada's Thunder Bay. To return via the St. Lawrence Seaway, the ship must navigate the locks of Sault Ste. Marie and the Welland Canal bypassing Niagara Falls. Sets of 500-ton doors* ***(right)*** *give access to eight Welland locks that lower vessels 327 feet between Lakes Erie and Ontario.*

merchant, wrote of his trip through Michigan's Upper Peninsula 26 years before: "It was then an unbroken wilderness, save one solitary trading post; and little did I think I should live to see on it so many populous towns . . . mining villages, stamp mills, smelting works, with steam ferries and steamboats plying between them."

During the California gold rush, a rush for timber, copper, and iron began in the Great Lakes basin. As the cities and towns grew, rivers and harbors were dredged and wetlands filled. Waste and sewage accompanied the cities, harbors, and mines. Who could guess the consequences? The lakes, as always, appeared infinite and invulnerable.

Penny canoed the Straits of Mackinac. I drove across them. The Mackinac Bridge rises almost 200 feet above the point where Lakes Huron and Michigan meet. It is the only place where you can see the sun rise on one of the Great Lakes and set on another.

I descended on the Upper Peninsula, where nature still rules. Driving west, then north, I came to the smaller Keweenaw Peninsula, which thrusts 60 miles into the heart of Lake Superior. Here cliffs, small mountains, and lovely inland lakes define the landscape, severe and rugged. Harsh shoreline of tumbled basalt and conglomerate rock is whipped by a hard surf. In winter there is an average of 20 feet of drifted snow.

For all its purity this region has not escaped injury by man. In fact, not far from here, across some 50 watery miles, the first alarm was sounded of a new pollution peril.

ISLE ROYALE sits in Lake Superior just south of Canadian waters, a half-day's ferry ride from Michigan's Keweenaw Peninsula. You can't see mainland Michigan from Isle Royale, although it is in that state.

No automobiles are allowed, no factories. At night there is an occasional wolf howl, or the thrashing about of a moose. The National Park Service maintains a small presence.*

Hardly a place to find toxic chemicals.

*See "Isle Royale, A North Woods Park Primeval," by John L. Eliot, in the April 1985 GEOGRAPHIC.

RICHARD OLSENIUS (TOP); BOB SACHA

A "hot spot" *of the Great Lakes, the Detroit River receives sewage effluent from scores of municipalities; its sediments contain hundreds of contaminants. One of a host of industrial complexes on the river, the Great Lakes Steel plant* ***(left)*** *belches steam; the firm has spent 150 million dollars in recent years to reduce toxic emissions, most of which are invisible.*

Environmental issues figured in the job loss of George Johnson ***(top,*** *at center). His employer, the Reserve Mining Company of Silver Bay, Minnesota, closed after it was forced to stop offshore dumping of tailings that left a carpet of carcinogenic asbestos fibers in western Lake Superior. His sons Scott and Rick and brother Roger are also looking for work.*

In eight years Michigan has had a loss of almost 20 percent in its autoworkers. Under a joint program of Ford Motor Company and the United Auto Workers, Dearborn assembly plant employees like Ernest Travich ***(above)*** *learn new skills to enhance their futures.*

Yet, in the mid-1970s a research team discovered PCBs—polychlorinated biphenyls—in fish samples taken from an island lake. They were at twice the levels found in surrounding Lake Superior.

Wayland Swain headed that team. He now teaches at the University of Amsterdam in the Netherlands, but I caught up with him at a water-quality conference in Detroit. "We had no clue as to how these chemicals could have gotten there. I thought we must have made a mistake."

What followed was frantic checking. Were there unknown toxic waste sites or faulty transformers or hydraulic power systems? They are all sources of PCBs. But there were none of these on the island. Finally, Dr. Swain told me: "We sent the fish samples for analysis with the newer, more sensitive gas-chromatography instruments and found toxaphene!"

A deeper mystery, for nowhere in the lakes area was toxaphene, an insecticide, commonly used. But here, also, was a clue.

The first thing that became clear was that the PCBs and toxaphene had been lumped together in the earlier, cruder chromatograms. And where did the toxics come from? The toxaphene likely came from the South, where it was used to combat the boll weevil until it was virtually banned in 1982. The PCBs could have come from anywhere, for they were then in wide use. One thing was certain: Neither the toxaphene nor PCBs could have come from Isle Royale. "With a little detective work we concluded they had arrived in the atmosphere and washed down in precipitation," Dr. Swain told me. Eventually the team found 12 other compounds in fish on the island. "They all came by air."

Toxic rain—more formally, atmospheric deposition of toxics—is an increasing concern of scientists studying Great Lakes water quality. If toxics can float in from anywhere, they shudder at the prospects for managing the problem anytime soon.

Consider dioxins: A Pollution Probe Foundation report found that the intake of this now notorious family of chemicals through food was 66 times higher in Toronto than is considered safe.

But are the Toronto findings valid for the

Great Lakes region? Some researchers doubt it and await results of wider testing.

Thomas Rahn of Canada's Pollution Probe believes the dioxins reached Great Lakes farmlands by air: "From garbage incineration mostly. Hydrocarbons and chloride in plastics are the building blocks of dioxins."

Airborne toxics are only the most recent threat to the health of the Great Lakes. Scientists, governments, and environmentalists have been worrying about others for years. In this region, where industry has been king for 150 years, protecting water quality is a constant challenge.

Until the 1950s the lakes were widely considered too immense to be polluted by man. But by the 1960s Lake Erie was unofficially proclaimed "dead," a victim of eutrophication, the accelerated aging resulting from the dumping of phosphorus-laden waste and sewage. As a result, Erie had become matted with thick green algae; the air at times stank of dead fish.

Lake Erie's fate added impetus to research for solutions to the region's problems. Erie's problems eased with the banning of phosphates in laundry products. And in 1972 the U. S. and Canada signed the Great Lakes Water Quality Agreement, a blueprint for improvement. Since then they have together spent almost nine billion dollars on sewage plants. Stricter controls have also been placed on industrial waste water.

TODAY Lake Erie sparkles, as do all the other lakes. But they are by no means pure. The IJC has verified nearly 300 chemical compounds in the Great Lakes. Many are considered potentially dangerous to humans. These include suspected cancer-causing aromatic hydrocarbons like dioxins, mirex, and PCBs . . . especially PCBs, now banned but nearly indestructible, once used widely in transformers, printer's ink, and dyes.

Toxics are insidious. Unlike conventional pollutants—say raw sewage—they are invisible and odorless in the water. Furthermore, some are persistent; once in the body, they stay.

For the most part they are found at low

D. GORTON (FACING PAGE) AND BOB SACHA

Shock troops for science, *Pekin ducks forage near a steel plant at Windermere Basin—a waterfowl wintering site on western Lake Ontario. The Canadian Wildlife Service uses the ducks to test pollution effects. After six weeks most ducks had high levels of lead and PCBs—and most died. Better earthbound than airborne, coal dust is controlled by water spray (**above**) at a steel mill on Lake Ontario's Hamilton Harbour.*

Gambling with fate, *Ray Cummins of Ludington, Michigan, boils chinook salmon in his backyard, fully aware that the Lake Michigan fish in his diet has increased the levels of PCBs and DDT in his blood. State researchers are tracking his health, along with that of 571 others, to determine long-term effects.*

water levels. Organisms like plankton pick them up. In turn, small fish that feed on these organisms accumulate increasing concentrations, especially in their fatty tissue. And so on up the food chain, all the way to humans who eat the fish.

And how big a threat are they to us? Scientists are only beginning to understand.

On Ohio's Cuyahoga River sunlight cut through the spray in the wake of our small boat, creating little rainbows. We pulled alongside a buoy. "I see fish," Kyle Hartman yelled, pleased that despite cold weather three brown bullheads were in the trap net that Stephen Smith and Dr. Paul Baumann, of the National Fisheries Contaminant Research Center, lifted out of the water.

One bullhead seemed to be looking right at me with a sort of desperate grin, its lips red and swollen with tumors. "I guess he hasn't seen his orthodontist yet," Steve said with a grim laugh.

All three bullheads had skin lesions, as did four of the eight fish we ultimately pulled out of the river that morning. Dr. Baumann and Dr. John Harshbarger, who directs the Smithsonian Institution's Registry of Tumors in Lower Animals, were on the Cuyahoga to study the effect of toxics on bottom-feeding fish.

THERE is hardly a better place for this than the Cuyahoga. Each year upwards of 740,000 pounds of metals and 95,000 pounds of organic pollutants are discharged into the river system.

The Cuyahoga is infamous. In 1969 it caught fire. The culprit was a spill of hot slag into a river whose surface was more oil, chemicals, and debris than it was water.

The river has not recovered quite so dramatically as Lake Erie. Upriver, where paper mills and steel plants share the banks with derelict lift bridges, I saw bubbles of methane floating on the scummy surface.

We brought the bullheads to Dr. Harshbarger, who had set up a makeshift lab inside a garage at the Army Corps of Engineers' pier in Cleveland. "The fish act as sentinels," Dr. Harshbarger told me as he began cutting out their livers with scissors and, using tongs, placing them in small jars. "These I'll take back to Washington."

Back at the Smithsonian he found liver tumors in four bullheads. An advanced liver cancer and a skin cancer were found in a freshwater drum we caught. "With them you can make an extremely strong case; with skin lesions, a good case." Since liver tumors rarely occur spontaneously, Dr. Harshbarger told me later, "anytime you get that many tumorous changes in the liver, you have an indication of chemical carcinogens in the water."

In earlier research, conducted where Ohio's Black River empties into Lake Erie at Lorain, Dr. Baumann found that brown bullheads had a 30 percent prevalence of grossly detectable liver-cell and bile-duct-cell cancers. However, he cautioned me: "It's almost impossible to go into the waterway and say, out of thousands of chemicals,

PAUL BAUMANN, U. S. FISH AND WILDLIFE SERVICE (ABOVE); BOB SACHA

Lip cancer *on a bullhead indicates carcinogens in Wisconsin's Fox River. In more contaminated tributaries, fish cancer rates may reach 84 percent. At Roswell Park Memorial Institute in Buffalo, New York, trout fry injected with carcinogenic benzopyrene glow under ultraviolet light in a test to find which toxics cause tumors.*

which precise sequence caused cancer."

Questions! There were always questions to ponder everywhere I traveled around the lakes. None struck me as more urgent than whether effects on humans are showing up.

Can those who eat large quantities of Great Lakes fish expect cancer or nervous system disorders sometime later in life? Will the children of mothers who eat contaminated species be born with defects? Do heavily polluted waters pose a danger to those living beside them?

To my surprise, I rarely came across human epidemiological studies. Even the Love Canal seemed forgotten insofar as what might be showing up among those hapless victims of pollution along the Niagara River, where even today millions of tons

of chemical waste is spread among 215 dump sites. Although most residents near Love Canal have been evacuated, there has been a lag in effective medical studies.

As for fish, the Great Lakes states and the province of Ontario issue consumption advisories. They warn pregnant women and nursing mothers to avoid eating certain Great Lakes fish. They also advise the rest of us to avoid eating certain large fatty species and to limit the consumption of others.

However, fishing and recreation represent big money in this era of industrial decline on the Great Lakes. So state officials are understandably cautious about alarmist predictions when so little is known.

Dr. Harold Humphrey of Michigan's Public Health Department has been studying 572 people who eat large amounts of Lake Michigan fish. Their blood may show 23 parts per billion of PCBs. But Dr. Humphrey's findings so far do not seem alarming. "None of their medical events stand out. They are not unique in terms of health problems." However, he added: "We cannot write the final chapter on this until we learn what happens to the fish-eaters when they grow old."

More disturbing were the findings of psychologists Greta Fein of the University of Maryland and Joseph and Sandra Jacobson of Wayne State University. They have been observing infants born to mothers who eat certain species of Lake Michigan fish. They find that PCBs reach even the fetus and that exposure continues through nursing.

And the effects? There have been some "developmental delays," Sandra Jacobson told me. The effects are subtle, and "we can't say they're permanent." The exposed infants were found to be somewhat smaller at birth, and at seven months they showed poorer short-term memory.

WIDESPREAD CONCERN is spurring action. Speaking before a U. S.-Canadian water quality summit conference held by the Center for the Great Lakes last November, Michigan Governor James J. Blanchard outlined a strategy aimed at freeing the lakes of unsafe levels of toxic materials by the year 2000.

He also proposed creation of a Michigan Great Lakes Research Fund to monitor problems and trends. "We can no longer be content simply with regulating after the fact," said Governor Blanchard.

There has been limited progress. All eight lakes states now have programs to control toxic discharges into the lakes. In May 1986 governors from the Great Lakes states signed a toxic-waste agreement. And in September environmental regulators from those states agreed to a nonbinding pact calling for a series of meetings in 1987 to devise common approaches for controlling toxic pollution.

A sign that cleaning up the Great Lakes has become a national issue came with passage of the Clean Water Act reauthorization in February. An amendment sets up a Great Lakes Research Office under the National

Giving nature a hand, *Michigan fisheries technicians stock Lake Superior with trout yearlings (**right**), even though the species has begun to reproduce naturally for the first time in decades. U. S. and Canadian agencies report gains in joint programs to balance stocked and prey species, keep the sea lamprey in check, and manage all fisheries cooperatively. After more than a century of decline, some lakes species (**above**)—particularly lake whitefish and yellow perch—are now on the increase, bolstering the economic potential of both sport and commercial fisheries.*

PAINTING BY DAVID WELTER; RICHARD OLSENIUS (ABOVE)

Oceanic and Atmospheric Administration.

Admittedly these are just beginning steps. But Dr. Wayland Swain is hopeful: "We have the technology to rid ourselves of these toxic wastes. If we get started on research for cost-effective disposal, we likely will find a solution for the future, although it may be a bit late for those already contaminated."

IS IT TOO LATE? I don't think so. And one of the reasons is my friend Dr. Jack Vallentyne, known to thousands of children around the world as "Johnny Biosphere." He thinks pollution will get worse before it gets better. But it will get better, he believes: "The people will wake up before it gets as bad as it can be."

As Johnny Biosphere, he has decided that the best place to begin turning the problem around is with young children. I joined him one delightful morning at an assembly of fifth and sixth graders at the Niagara Street School in Niagara Falls, New York, a few miles from Love Canal.

Standing before the students in a brown safari suit with a globe strapped to his back, he asked: "See anything strange?" One boy thought the straps were part of a parachute. Another thought he carried an oversize lunch. "I carry a globe with me whenever I go more than ten miles from home," he told them, "as a reminder of the importance of earth." The word "biosphere" was stamped on one strap; on the other, "ecosystem."

The students settled in for an assembly of fun with this odd professor. His globe lights up "if the person who touches it has done something good for the biosphere." A tape

Far from urban hot spots, the wetlands of Wisconsin's Sturgeon Bay offer

recorder hidden in his backpack makes the sounds of an elephant, a humpback whale, a wolf, and a nightingale. "They're saying: 'Hey! Don't forget me. I'm here too.' "

Fun . . . yes, even for adults, but Johnny Biosphere has a serious message as well. To illustrate acid rain, he divided the assembly into U. S. and Canadian areas. The students squealed delightedly when he suddenly squirted them with a bottle of rainwater. But the laughter ended abruptly when one student thought to ask: "Is this really acid rain?" Worry and doubt crept across their young faces when he replied: "Yes, this is real acid rain from my home in Canada."

Later he produced a sickly potted plant and said, "Since we're so smart, maybe we can save it." He took a bag of potato chips out of his knapsack and sprinkled them on the plant. The students yelled "No-o-o-o!"

He acknowledged that the plant seemed no better. "Maybe it needs some water." He took out a soft drink and to the dismay of the young assembly poured it over the plant. He shrugged: "Not any better, I see."

LIKE JACK VALLENTYNE, I hoped that some of these students would be inspired to think about, and one day help reduce, the environmental price of progress and prosperity. Restoring and maintaining the good health of the Great Lakes will be the job of more than a single generation.

Says Johnny Biosphere: "Perhaps they'll realize that the junk they put into their ecosystems will return to haunt their children."

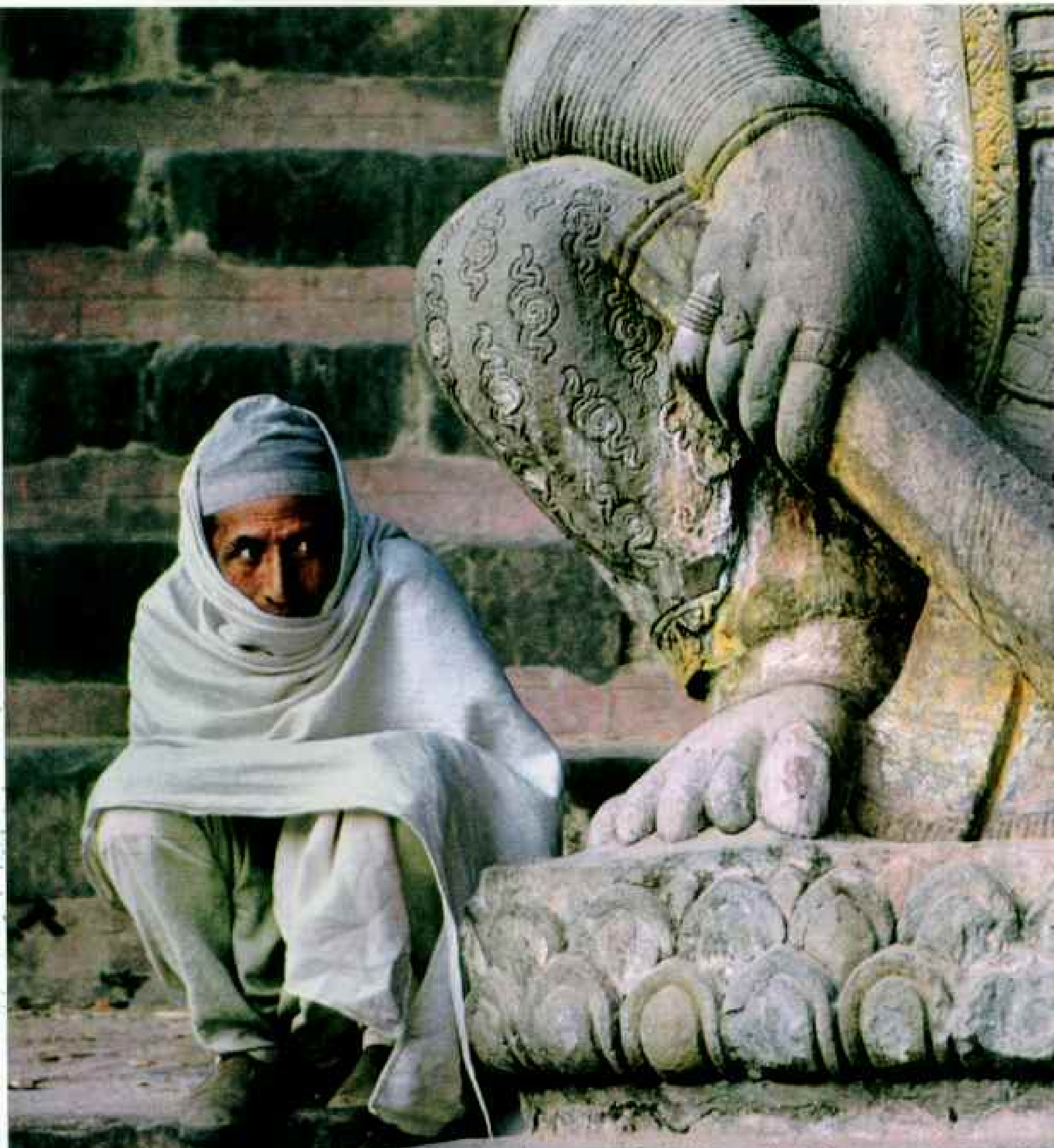
Perhaps we will too. □

refuge for swans and other birds, and inspiration for conservationists.

RICHARD ELSENIUS

New Forces Challenge the Gods

At the Crossroads



# of Kathmandu

TOLERANCE is the spiritual glue that has long held together the people of Nepal's Kathmandu Valley. Here great religions mingle, and thousands of gods merge. Almost all are embraced by the Newars, probably descendants of the valley's original inhabitants. Newars, about half the population, speak a language separate from that of their Nepalese neighbors. Half a dozen other ethnic groups intensify the mosaic.

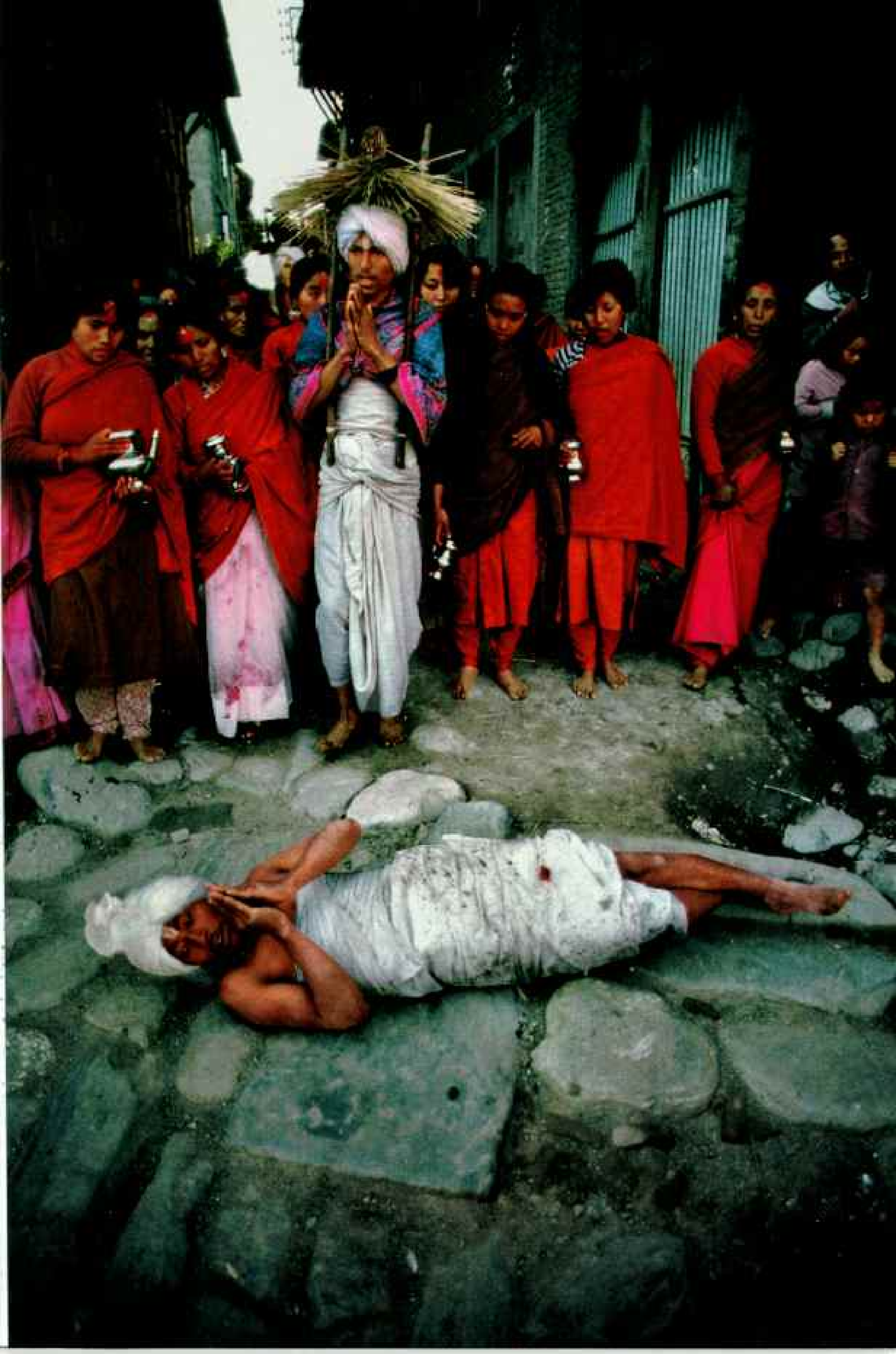
But tolerance may no longer be enough. A Nepalese (left) seems to cast a watchful eye beside an image of a wrestler believed ten times as strong as an ordinary man. Will Kathmandu's powers that be have the strength to deal with a booming population, land-use questions, and the cult of Western materialism?

By DOUGLAS H. CHADWICK

Photographs by
WILLIAM THOMPSON

Swirl of trade *around a tiny Hindu shrine colors the Asan Tol market, offering a miscellany of goods such as garden-plot tomatoes. This main street in the capital city of Kathmandu is an ancient route linking Nepal, Tibet, China, and India.*

Such a heady atmosphere—along with once legal drugs—drew flower children from the West in the late 1960s and early '70s. They melted away, but some, reincarnated into a more prosperous life, are returning as tourists to boost the economy.



BEFORE ME is what looks like a small, serene idol. It is in fact a beautiful child, eyes outlined in black ointments, dark hair gleaming with mustard oil, relieving herself in the street. I try to move left but bump into a businessman's briefcase. Nudging right, I'm nudged back by a bull wearing a necklace of marigolds. Pressed from behind by a piping flute seller, I step over the child as a bus blares up the narrow brick canyon, missing us all by inches. Within its coils of exhaust a man painted orange, carrying a snake-headed staff, takes form, nods at me, then vanishes behind a jostle of teenagers with stereo headphones working out their rock 'n' roll moves. Pagodas that writhe with erotic carvings thrust roof upon roof above the trees, where big bats hang like fruit. And above the rooftops pure white snow peaks reach upward toward the stratosphere. At the moment all I'm looking for is the local computer club—somewhere in the magic confusion of modern Kathmandu.

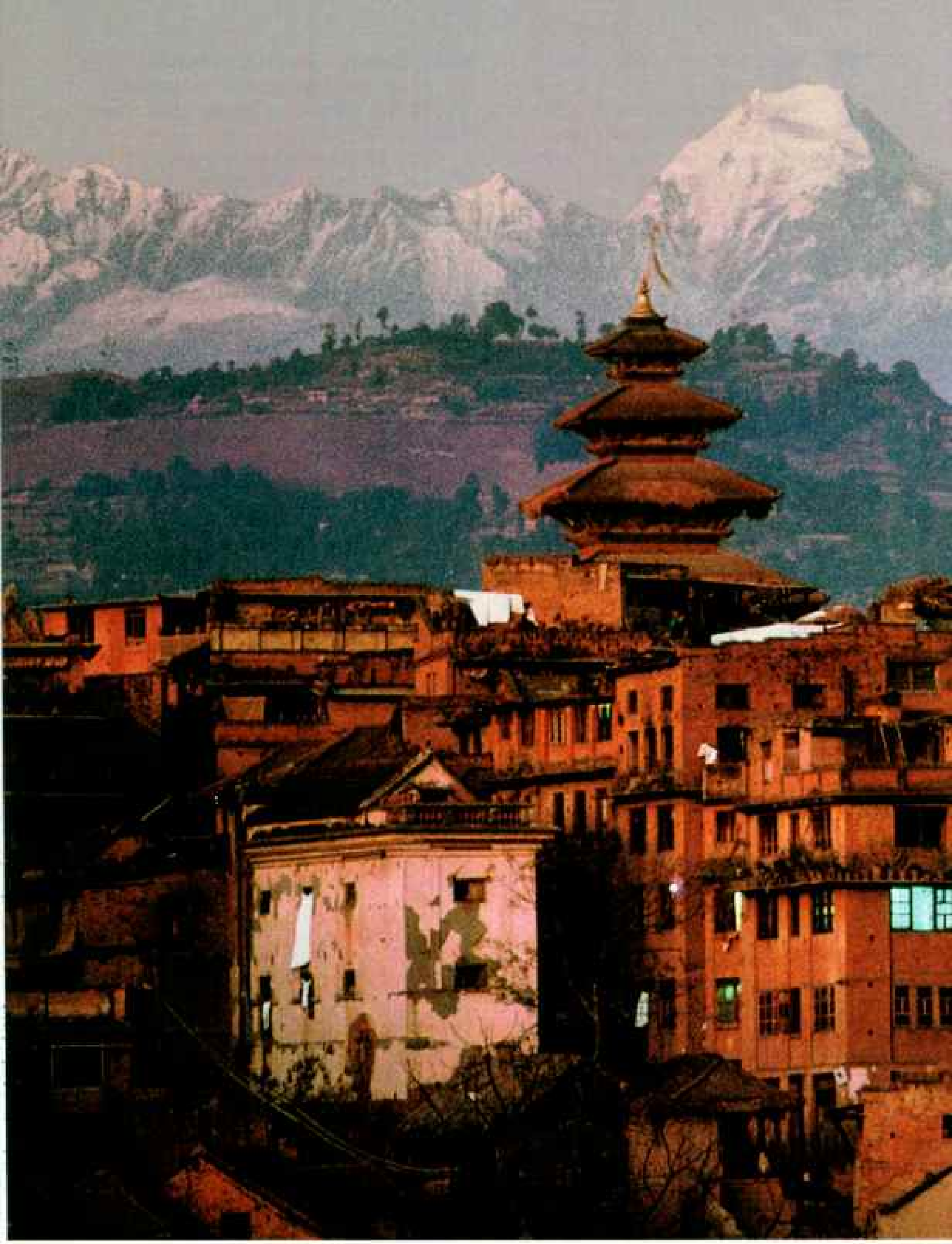
I once met a Nepalese hillman along a switchback trail and asked where he was bound. He pointed to Kathmandu. But he said, "Nepal."

For many in this diverse nation, Nepal remains one and the same thing as the fabled valley at its heart. Folded deep between the Mahabharat and Himalayan ranges, the Kathmandu Valley, lying at the same latitude as Florida, is barely 4,400 feet high. Long ago, legends say—and geologists agree—a lake covered the valley floor. Earthquakes helped build it. And, they say, a god drained it, taking a burning lotus from the waters to make the hill called Swayambhu. In the dawn a great dome with a spire of hammered gold begins to glow on Swayambhu as if the lotus still flamed, and long silvered trumpets chant while pilgrims circle the shrine with prostrations—a human prayer wheel that has been in motion for perhaps 2,000 years.

The valley, with its fertile layers of lake-bottom sediments, covers little more than 12 by 15 miles. Yet ancient peoples and cultures from every direction have settled within it. Major trade routes linking the empires of India with those of Tibet and China intersected in the sheltering vale. "That this would become a powerful trade center in its own right was a geographic inevitability," Dr. Harka Gurung, a former government minister, told me.

From the crossroads arose not one city but three Himalayan city-kingdoms: Kathmandu, the largest; Patan, just across the sacred Bagmati River, a tributary of the Ganges; and Bhaktapur, eight miles to the east. A succession of rulers—the Licchavis, Thakuris, Mallas, Shahs, and Ranas—left some 3,000 important historical monuments nestled between the *(Continued on page 44)*

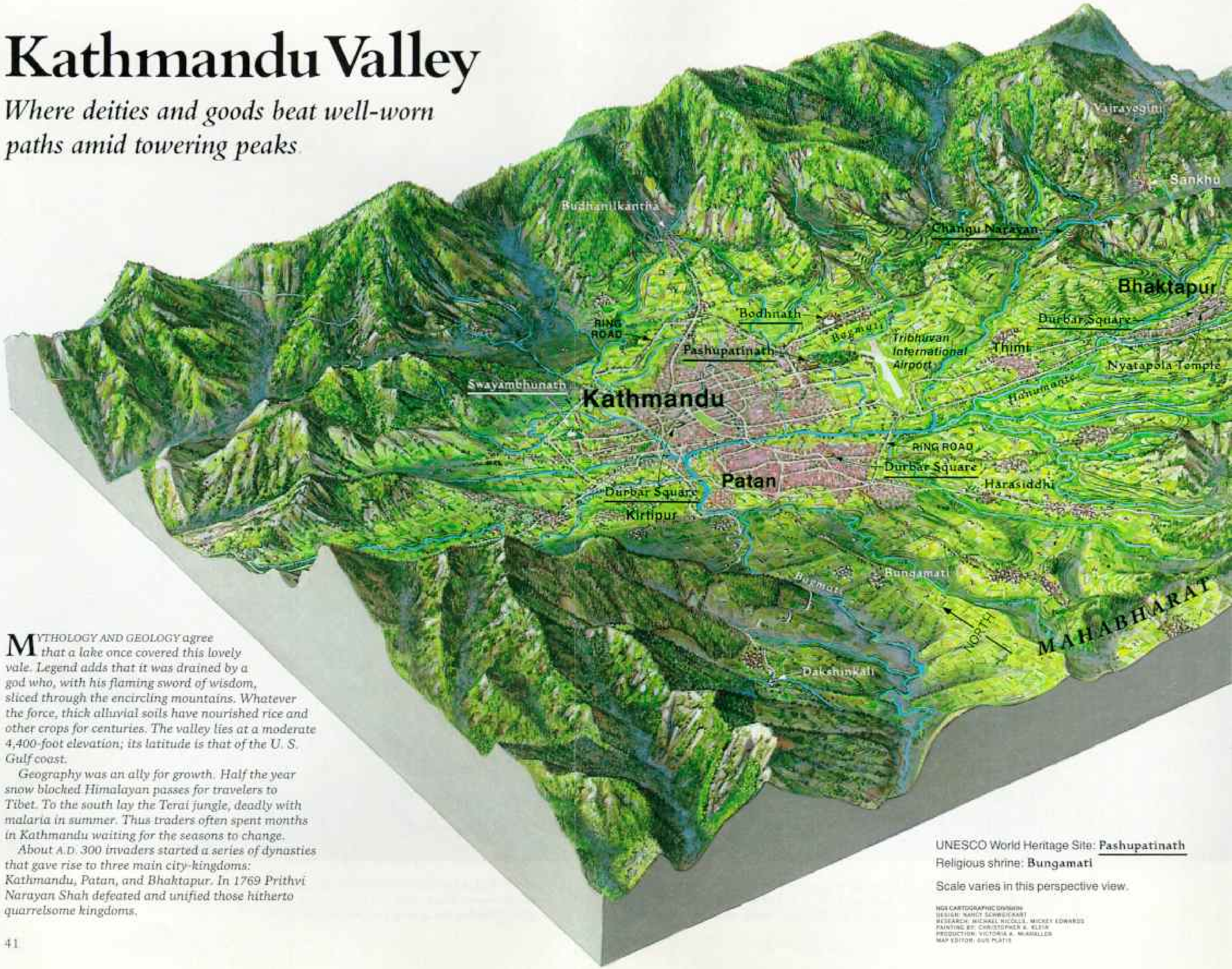
Sacred and mundane: *A Hindu rolls through the town of Sankhu (**facing page**) to gain merit during Svasthani Vrata, a festival devoted to fasting and ritual bathing. Foreign currency is revered in Thamel (**above**), a Kathmandu district of cafés and trekkers' shops catering to 200,000 visitors a year.*



Abode of the gods, *Himalayan peaks glow at sunset, with Dorje Lakpa rising to 22,930 feet at center. Below stands Bhaktapur, City of Devotees, eight miles east of Kathmandu. Its lights first winked on in the early 1960s, when the city was electrified. A typical Newar town with tight clusters of densely packed multi-story houses, Bhaktapur has a strong Hindu heritage, and its artisans have long specialized in the dyeing and printing of cloth.*

Kathmandu Valley

Where deities and goods beat well-worn paths amid towering peaks



MYTHOLOGY AND GEOLOGY agree that a lake once covered this lovely vale. Legend adds that it was drained by a god who, with his flaming sword of wisdom, sliced through the encircling mountains. Whatever the force, thick alluvial soils have nourished rice and other crops for centuries. The valley lies at a moderate 4,400-foot elevation; its latitude is that of the U. S. Gulf coast.

Geography was an ally for growth. Half the year snow blocked Himalayan passes for travelers to Tibet. To the south lay the Terai jungle, deadly with malaria in summer. Thus traders often spent months in Kathmandu waiting for the seasons to change.

About A.D. 300 invaders started a series of dynasties that gave rise to three main city-kingdoms: Kathmandu, Patan, and Bhaktapur. In 1769 Prithvi Narayan Shah defeated and unified those hitherto quarrelsome kingdoms.

UNESCO World Heritage Site: **Pashupatinath**

Religious shrine: **Bungamati**

Scale varies in this perspective view.

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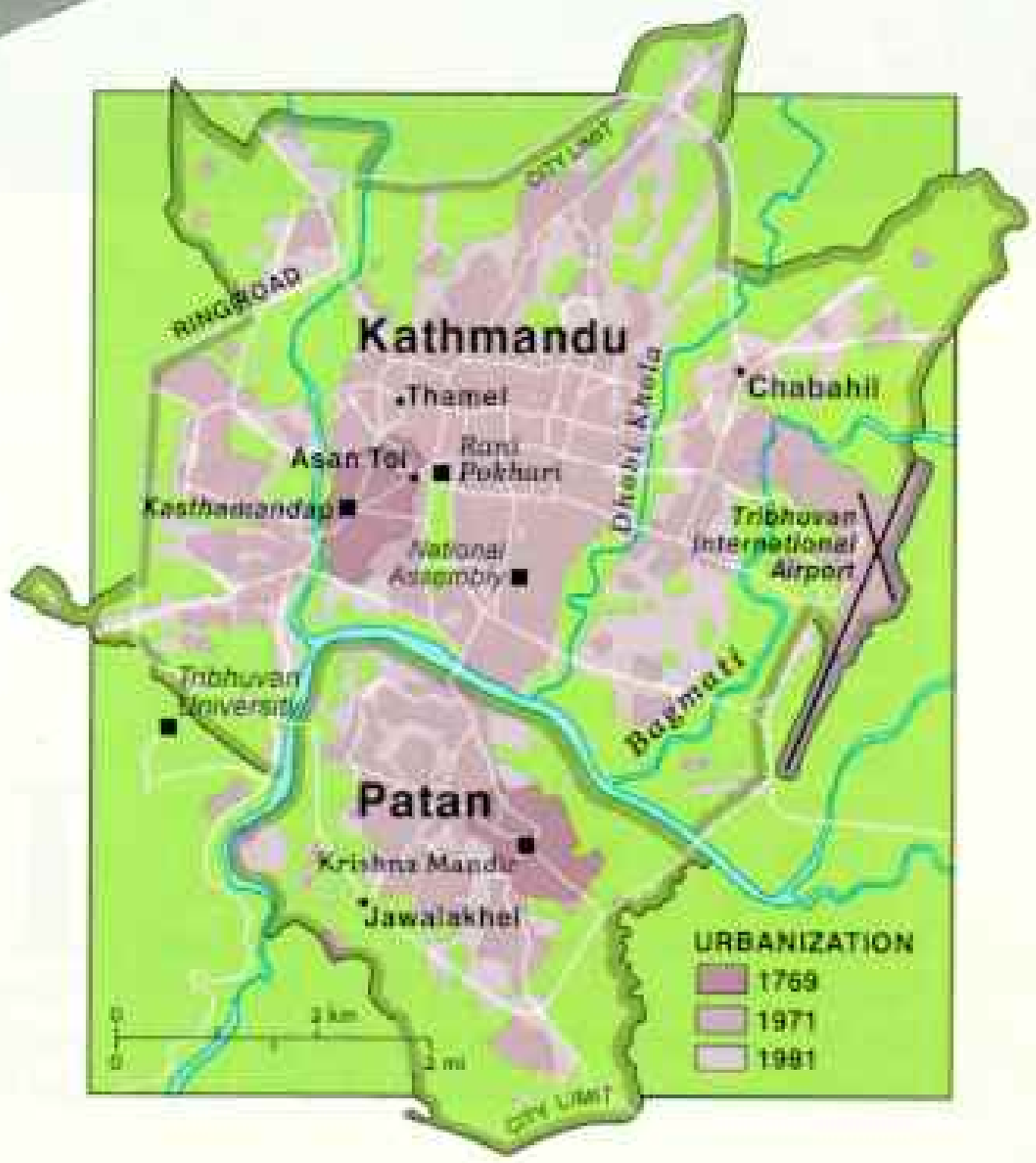

*Explosive growth reaches out from Kathmandu and Patan (**right**); development in Bhaktapur, farther east, has been more moderate. By the 14th century the towns had developed core centers. After an era of national isolation that began in 1769, the overthrow of the Rana dynasty in 1951 opened Nepal to an influx of aid and immigrants. Since then increasing infrastructure has tripled the area of the Kathmandu-Patan complex.*

The monarch lives on *in a life-size cutout photograph of the late King Tribhuvan, paraded once a year* ***(above)****. In 1950, while under virtual house arrest by the Rana family, the king escaped and soon overthrew the usurpers. His grandson,*

mountainsides. Most of them are religious, and many are more actively used than ever. Seven, including Swayambhu, have been placed on UNESCO's World Heritage List—the densest concentration of such sites anywhere. For all that, a fabric of croplands and thatch-roofed hamlets still covers three-quarters of the valley, its rich agricultural heritage having been preserved as well.

Over this legacy—this living museum, said to hold as many gods as men—reigns Nepal's king. His Majesty King Birendra Bir Bikram Shah Dev is considered a god himself—an incarnation of the Hindu Lord Vishnu with a Harvard education. Counseled by an elected National Assembly, he guides a nation whose traditions, both sacred and feudal, are fast being transformed, having met the mysterious West head-on at the crossroads of Kathmandu.

IN ASAN TOL, the leaning, labyrinthine brick core of Kathmandu city, one of the old trade routes runs by an open stall, tiny and fragrant. Sushila Shrestha, a seven-year-old Newar, and I are packing valley-grown ginger into a bag. Sushila's father, Balram, just sold a pile to a

*King Birendra Bir Bikram Shah Dev (**top**), seen with Queen Aishwarya, now rules and is regarded by many as a deity. On his birthday the king, who is supported by most of the military, is saluted by top generals (**above**).*

Gurung, who will take it to sell at his own spice shop three days' walk to the west. A Brahman woman stops by next for *jimbu*, an herb from the upland cliffs, but rejects Balram's sample with an imperious sniff. Balram shrugs, "*Ke garne?*—What to do? Does she want perfume?"

Then come a Tamang couple, arrived from the hills this morning with goats, potatoes, and a little firewood to sell and trade. They want cumin from beyond the lowland tiger forests. If Sushila had her way, they'd get plenty in exchange for the Tibetan mastiff puppy poking out of the man's coat.

A Newar from Bhaktapur shows up to squat beside us. He talks of everything except what's on his mind, which is to win a good price from Balram for his garlic crop. Eventually the men switch from the national tongue, Nepali, to their native language, Newari, and a deal is struck.

Balram's scale hangs from an antique beam carved with nagas, or serpents, primal

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Douglas H. Chadwick has contributed eight articles to the GEOGRAPHIC and is at work on a ninth. **William Thompson** has covered subjects from Alaska to Bhutan for the magazine.

Frenzied tug-of-war *is staged by residents of the eastern and western sectors of Bhaktapur during the week-long Nepalese New Year's festival called Bisket, held in mid-April. Competitors fore and aft vie for the prize: a huge chariot containing*

the Hindu deity Bhairava. Later the chariot will be hauled to the Hanumante River, where an 80-foot pole is erected, adorned with two banners representing serpents, and felled the next day to mark the onset of the new year.

earth and water spirits; in the electric hush just before a storm, you might feel them calling forth thunder and rainbows. The spice stall is the lower porch of a temple virtually woven with statues of deities and symbolic designs from the Newars' unique fusion of Hinduism, Buddhism, and an earlier animism. Though no one is sure where the Newars came from, they had emerged by A.D. 900 as the valley's dominant ethnic group and foremost artisans. These people couldn't stand to leave a piece of wood, metal, or stone unadorned, it seems.

As his father before him, Balram rents the space from a neighborhood association, or *guthi*, which provides for temple upkeep, the welfare of its members, and the many ceremonies that attend each Newar from birth through burning on the funeral pyre.

DURING the renaissance reign of the Malla dynasty, which began in 1200, Newar merchant colonies flourished abroad. In

the valley, steadily enriched by trade and tariffs, princes turned the city-kingdoms into rival showcases of grandeur, each crowned by its *durbar*, meaning palace, square. The real winner was Prithvi Narayan Shah, who forged relentlessly from the Gorkha province—we know its soldiers as Gurkhas—to conquer the divided Mallas in 1769. He went on to establish the nation of Nepal, with Kathmandu as the capital.

The Newar brick-and-carved-wood pagoda style of architecture is unique to the

Fields never lie fallow *where immensely rich soil yields three harvests annually. The valley is nearly self-sufficient in food grains. Every arable square foot is cultivated, such as the new fields creeping up slopes in the foreground. But urban growth reaches out for this land like gods demanding sacrifice. A study warns that in little more than 30 years, 60 percent of the valley, including its best farmland, may be swallowed by development.*

Kathmandu Valley. But few foreigners ever saw the forests of temples glittering here. Prithvi Narayan Shah launched a policy of isolationism that would close or restrict Nepal's borders for nearly two centuries.

In 1846 the Rana clan usurped power, reducing the Shah king to a mere figurehead. They funneled state treasure into the construction of extravagant mansions—temples of worldly pleasure. In 1951 a popular uprising aided by newly independent India restored King Birendra's grandfather, Tribhuvan, to power, and the nation was opened to the world.

At that time the valley had about 400,000 inhabitants. The first automobiles had already arrived, packed over the Mahabharat Range on litters for the elite—and carried back for trade-in. By 1956 a highway linked the once remote capital to India. Today, "it is only the supreme grace of the god Pashupati [Siva] that explains our survival in this traffic," I'm told by a government official. Whirling like Pashupati's cosmic chaos of creation and destruction, the whole affair flirts daily with total gridlock in a growing pall of smog. There are foot traffic jams as well, for the valley now holds nearly one million of Nepal's 17 million souls.

More souls spill down every day to the same medieval streets—and to sewage and water-supply systems that are in places equally antiquated—from overfarmed hills and mountainsides, where families have an average of six children each. Tibetan refugees account for perhaps 10,000 of the immigrants of the past three decades. Another 40,000 or more are Indians, mostly from the impoverished Gangetic Plain and willing to fill menial jobs for low wages. Though Nepalese have a long tradition of hospitality toward neighbors, many have begun to fear that this uncontrolled tide from the south could engulf them. And then each year some 200,000 tourists—one for every five residents—pass through the valley as well.

IT'S A FINE TIME for tourists in search of new scenes, this October fortnight called Dasain. But it's a risky time to be a duck—or a chicken, or a young male goat or water buffalo. All Nepal is commemorating the victory of its protectress over the forces of evil. She is mother goddess Durga, fierce Kali, mysterious Taleju—and she will have sacrifice.

So the ducks shift uneasily in wicker cages as sparks fall on their backs from knives being honed. The altars already glisten with offerings of vermilion—powder and flowers. The buffalo is stretched at the post. Sweets are stuffed into the mouths of fanged idols. Children fill the sky with kites while the hawk-like scavengers known as kites soar between them. Rumors make the round that human sacrifice, practiced until a century ago, still occurs in some secret chamber. The goat's throat is bared. Astrologers announce that the time is at hand. . . .

And blood begins to seep through every street, mingling with the petals, flowing on and on until everything has been blessed and made safe, and I sit in Bhaktapur's Durbar Square ensnared by a faint scent of night-blooming jasmine, watching the bloated moon rise. Not one engine or electric light disturbs this smallest and oldest-feeling of cities this evening.

"And the wildest dreams of Kew are the facts of Khatmandhu," claims the oft quoted line by Rudyard Kipling. I'm wondering what the wildest dreams of Kathmandu are like. Nearby stands the Nyatapola Temple, higher, and, for me, lovelier than any other in the vale. It is said that the Malla king who built it had troubled dreams. Only he knew why.

This year Dasain coincides with the rice harvest. Grateful for open countryside, I wade the Dhobi Khola river with Indra Dangol to reach the fields of his family, members of the Newar farmer group known as Jyapus. As a line of women bends to scythe the ripe stalks, their singing rises and the red trim of black skirts lifts above slender tattooed ankles. From the next paddy come men's voices shouting out the chorus.

Barefoot on an earthen dike, I pass a shoe—held upside down on a stake. "For witches," explains Indra. "People with the evil eye can ruin your crops. But they won't want to look at the sole of a foot, the lowest part of the body."

Through the afternoon I help Indra's uncle, Krishna Prajapati, thresh high-yield Chinese rice. Clouds of egrets drift by as we whip the sheaves against the ground and the kernels spray loose under the golden sun. Then we pile the stalks for buffalo fodder and take a long sip of rice beer. The labor

Helping hand *of Nepal's government has given sanctuary in the Kathmandu Valley to some 10,000 Tibetans since their unsuccessful 1959 rebellion against China. In turn the immigrants contribute to the economy and their own welfare, as reflected by Tibetan youths (**right**) affluently dressed in Western fashion.*

*In the Jawalakhel handicraft center a Tibetan woman (**left**) spins wool for carpets prized by tourists. The industry is Nepal's largest foreign exchange earner after tourism and its largest private employer.*

begun months before—when Krishna broke the soil and worked buffalo manure into it and planted rice in time for the summer monsoon—is finally through. Now he lifts his hoe and begins turning the lake-bed sediments once more, to sow the winter crop of wheat and potatoes.

In the town of Thimi, Gyan Bahadur Prajapati squeezes a moist lump of soil from a slightly greater depth, gives his potter's wheel a spin, and begins to shape a serving bowl. His brother is in the backyard, stacking a thousand sun-dried vessels, from delicate cups to massive storage urns, in rows on beds of rice straw. Soon Gyan joins him in heaping ashes over the mound, then sets it to smoldering. "We are farmers first," he says, poking air holes in this kiln. "And out of 2,000 houses in Thimi, 700 also carry on the clay work we are known for. We trade our pots far into the hills and south toward India—these days by bus."

Others in Thimi turn out drainpipes, roof tiles, and bricks. The people's homespun cotton clothes are impregnated with orange clay. Their floors are of freshly swept mud mixed with cow dung, their roofs of straw or weathered tiles with grass sprouting from the seams. Like the blur of mud rising and flaring open under potter Gyan's sure hands, Thimi seems molded straight from the earth spinning on its axis.

The hive-like quality of Newar communities reflects family structure. You might find 30 people from four generations in a typical two- or three-story house, with stored produce and stalls for livestock taking up the ground floor. The compactness of villages also reflects the need to conserve every inch of arable land. With most of these rural communities confined to lake-bed ridges known as *tar*, gardens tucked even in the hub of Kathmandu city, and squash vines trained up onto rooftops to flower, the valley is nearly self-sufficient in staple crops.

These fields are among the most valuable in the steep-sided nation. But the cities are beginning to bulge across them, spinning concrete-box houses off the new Chinese-built Ring Road around Kathmandu and Patan. A 1986 study by Kathmandu Valley's Town Planning Office predicts that 60 percent of the valley, including all its prime agricultural land, may be buried beneath buildings by the year 2020. To keep pace with the demand for construction material, nearly a hundred brickyards, many of them the size of a football field, pock the vale, taking up a good share of key farmland themselves. They burn convoys of coal from India and logs from Nepal's dwindling woodlands. During winter, when they are busiest, their smudge, added to the haze from cook fires and automobile fumes, makes for days when you can scarcely distinguish the tops of the temples.

"Land prices keep leaping upward," says geographer Dr. Soorya Lal Amatya. "Some of our farmers who earn maybe $200 a year now own property worth a fortune but are reluctant to sell out. If it were not for the Jyapus' attachment to the land and strong community traditions, we would long ago have seen the kind of slums and suburbs that sprawl from other big cities."

ONCE Wangchen Ghuwa owned a wealth of livestock in eastern Tibet. After a three-year flight from an invading Chinese army, he reached the refugee camp in Patan's Jawalakhel quarter. On the march he had lost most of his family to fever, and his brother, a Buddhist lama, to bullets.

In Patan, Wangchen found a job mixing dyes at a center that the Swiss had helped set up to produce traditional Tibetan wool carpets. His surviving son, Ragpa, carried water for the camp; he is currently a cameraman for Nepal's first television station. Ragpa's wife, Buchi, used to work 16-hour days at a loom; she now oversees Nepalese weavers at her own carpet shop.

Holding their oldest son in his blue school uniform, Ragpa tells me, "The government of Nepal gave us many things. Most of all they gave us freedom—to work, to travel, to practice our religion. We can never thank this country enough."

Perhaps not in words. However, the

Bursting at the seams, *Kathmandu's population of 300,000 has doubled since 1960, and the valley's total has soared to nearly a million. The Rani Pokhari, or Queen's Reservoir, at center, was created by a 17th-century monarch to comfort his wife over the death of their son.*

Tibetan carpet industry is the valley's largest private employer of Nepalese. And the foreign revenue from booming sales of these thick, boldly patterned rugs is most welcome to a nation with few exports. In addition, the Buddhist shrine known as Bodhnath on Kathmandu's outskirts has become a window on Tibet for tourists, Nepal's chief source of income after foreign aid.

All-seeing eyes atop the ancient shrine watch as I make my way past Tibetan traders' camps where horses are tethered beside yak-hair tents; past Tibetan shops selling mystic stones, cheap Chinese sneakers, and drinking cups made of human skulls inlaid with silver; then past an array of new Tibetan monasteries to reach the sanctum of Chokyi Nyima Rimpoche. When Nyima was a child, elder lamas divined signs that he was the embodiment of a former leader. He was declared an incarnate lama of the Kagyupa sect. Hushed attendants wait by

The Hindu face *of Patan's Durbar Square (**left**) was rebuilt after a devastating 1934 earthquake. Krishna, in his temple at right, is adored by the god's companion, Garuda, atop a central pillar. In Kathmandu another Garuda image, created about A.D. 500 and probably the oldest of its kind in all Nepal, has unfortunately been half-buried by successive layers of pavement (**below**).*

the curtains for his arrival to a chamber that is an exquisitely painted cosmos filled with scrolls and gilded chests. He enters, and my gaze follows the sweep of his arm.

"All this—sort of show-off, yes? Tibetan people like these colors. For others maybe too much," he laughs. "We are starting more classes for Westerners. You will come meditate with me?" I will. "In Tibet, Buddhism was very strong, but not much contact with outside. Here we meet the world, and Buddhism spreads a little more. So some good is coming from our time of hardship."

In this crossroads valley it is only a short walk from Bodhnath to Pashupatinath, a window on India and its spiritual life. Among the most significant of all Hindu shrines, it draws devotees of Siva from a thousand miles south. While worshipers bathe in the Bagmati and rhesus monkeys belly flop off the cremation ghats, I stand in the smoke of incense and burning corpses to

talk with a living saint. He is the Milk Yogi. Nourished solely upon the sacred cow's white gift, his life is a long prayer for the glory of Ram. Upon the death of a king in Nepal, a Brahman priest will appear at these cremation ghats to eat a piece of the royal charred head. Having thus taken into himself the ruler's sins, he will ride away to India on an elephant, never to return.

I leave the smoky ghats on foot and climb the valley's northern rim, passing Brahman and Chhetri hamlets. Himalayan cherries are blossoming on tiers of pink buckwheat, yellow mustard, lime green millet. Higher up, patches of the old forest of chestnut, oak, and giant rhododendron remain, along with the occasional leopard and little wild golden cat. I'm seldom out of earshot of the thwack of axes though; these groves are getting smaller by the hour, turning into firewood and livestock fodder.

Yet farther on I find myself among young pines planted to restore forest cover and check the gullying soil erosion that has impoverished so many Nepalese hillsides. Beyond, eight of the planet's ten highest peaks are rooted in the sky. I can make out Manaslu, Everest, and Makalu, reincarnated in late sun colors.

KATHMANDU'S main tourist enclave used to be near Durbar Square, along an avenue dubbed Freak Street. That was where the footloose flowerfolk of the sixties congregated to loosen their minds. They'd found the hidden wonderland, man. I mean, amaaazingly friendly citizens; gurus galore; and, hey, *legal* hashish and marijuana. Shangri-Goodvibes-La.

Soon after King Birendra was crowned in 1975, drug sales were banned. The Universal Love and Pie-type cafés closed as the times kept a-changin'. By 1978, when I arrived on my first visit, the universe's hippest scene had joined Nepal's other bygone cultures. Today's visitors lodge mostly in the Thamel quarter, among trekking-gear shops run by Sherpa entrepreneurs and restaurants offering every cuisine.

Leaving an Italian restaurant, I find a beggar boy in burlap rags at the door. It's Kancha Tamang, a regular hereabouts. He ran away from home last year and no sooner

Bedrock in a changing landscape, *the Newar farmer caste known as Jyapu preserves traditions rooted in the dawn of valley history. A woman creates a warp of thread dyed and dried in the sun* ***(above)****; it is used in Jyapuni costumes. Their rice fields* ***(right)*** *could reap a windfall if sold for development, but many Jyapus have stood fast.*

Scurrying at night *to avoid deforestation restrictions, a woman hauls firewood to Kathmandu (***below***).*

*Ashes insulate bricks (***facing page***) made from valley topsoil, so deep that the layer beneath can be replanted.*

landed in the big city than an older boy gave him money to spend. Except, he learned, it was a high-interest loan. Not to worry; he might make ten rupees a day (about 50 cents)—half the wages of a sweating grain porter—just by putting his hand out in Thamel. Of course there was also a charge for using the area. . . . So Kancha joined a string of panhandlers supporting a young turf lord. And all that guy does, Kancha complains, is hang out at the videos—the popular, semi-legal parlors that show foreign videotapes—in his fancy Hong Kong clothes.

In just the past decade most young urban Nepalese have rejected traditional garb in favor of Western-style clothes. Though these and other mass-produced consumer goods come by way of Bangkok and Dhaka (Dacca), everyone just calls it the Hong Kong trade. Nepal places high tariffs on such imports but allows citizens returning from abroad to bring in a certain quota for personal use.

Ah, here comes the Monday flight in from Dhaka, Bangladesh, now. It's brimming with local ricksha wallahs and school kids. Each sports an identical wristwatch and polyester outfit and has more in his new suitcase, along with the allotted stereo system, electric appliances, and so on. Ah, here comes the merchant who paid their cheap fares. He hands out more rupees, collects the booty, hauls it off to sell at his "Hong Kong" store. Since it isn't exactly a black market, like the one for foreign currency here, call this the growing gray market.

Something else passes through Tribhuvan International Airport and along remote border trails. The banner I see at a busy intersection describes it: "The Second Name of Death Is Smack." Heroin. "Brown sugar" in its unrefined form. Cheap—just over a dollar a gram. And when you hold it on some foil, light a match underneath, and inhale the fumes—this you call chasing the dragon.

That's how most take the illegal drug here, like these teenagers in a grain storage room. "Very fine. Hooo, yes. Trying some?"

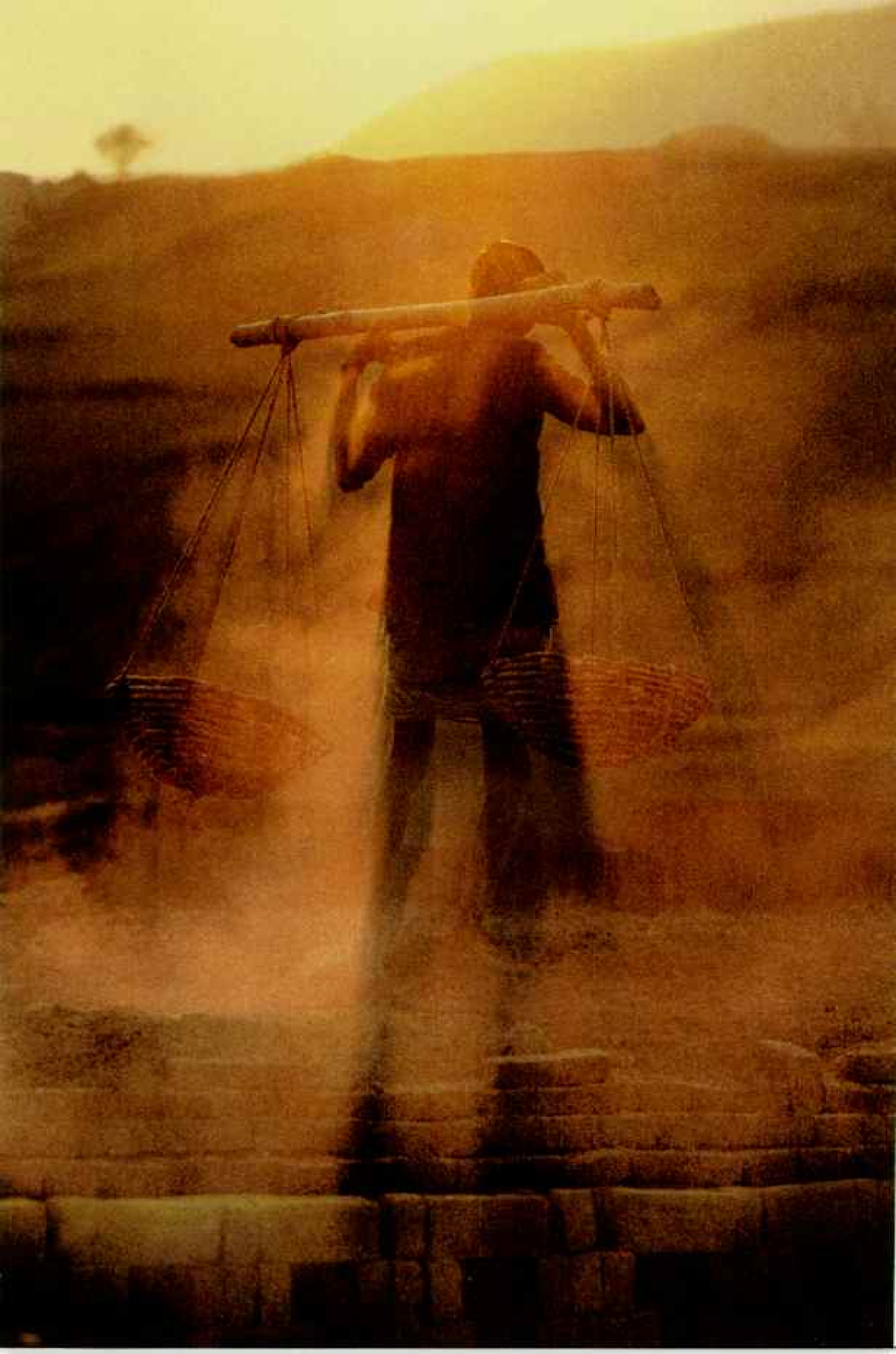
Three other users—a middle-class Newar college student, a Pakistani refugee, and a smuggler from the Manang region, all in their 20s—sit in a different room, undergoing withdrawal at the private clinic of Dr. Desh Raj Kunwar. How long did they think a dragon would run from a man?

"Blood was pouring from my nose this morning," the student tells me in a drool of words, wrapping his arms across his belly as if to hold himself in. Suddenly he's up, shouting, "I want to live! But I am afraid I will go back. . . ." I take his hand to steady him. So cold; I can't feel any pulse at all.

"First you smoke with money," says the hollowed Manang man, whose eyes seem about to slide off his face. "Then the money is finished and you have to deal. You get your friends on it. When you are sick like this, you will do anything."

Ten years ago Nepal had only 50 heroin addicts, officials guessed. At present there are an estimated 15,000 in the city of Kathmandu alone, involving one in every 20 young men there.

Some see the heroin epidemic as evidence of overexposure to Western influences and a breakdown of cultural identity. Others link drug abuse to high levels of unemployment and resulting frustration among the young.



Nepal's paramount deity, *Pashupati, one of the infinite forms of the Hindu god Siva, may draw 100,000 devotees to this Kathmandu Valley temple on Siva's Night in February or March. Many trek from India to the shrine, one of the most important sites*

in the subcontinent for Siva worshipers. In an inner-courtyard temple Siva's sacred lingam receives tribute. Outside, suppliants bathe in the Bagmati River, which one day may carry their ashes from cremation ghats at center to join the Ganges.

Half the population is now under 21. In the past 30 years Nepal's literacy rate has risen from 5 percent to nearly 25 percent; the figure is higher still for the valley. But expectations have increased apace, if not faster. Can the government match them with new opportunities?

The valley's economic vitality was struck a blow in 1904, when the British forced open an alternate trade route from Calcutta to Tibet. Lacking many essential raw materials and a manufacturing base, the kingdom has been struggling ever since to pay for the imports that its swelling population depends upon. The main growth industry in modern Kathmandu has been government—a bureaucracy plagued by inefficiency and, officials admit, widespread graft.

I hear the rumblings of student discontent. "Competition for civil service jobs is quite intense," one tells me. "Salaries are low, but everyone expects to share in the bribes. Many students even bribe their teachers to graduate in the first place. How is one to overcome such a system?"

IN JUNE 1985 Deanna Benatovich, a visitor from Hawaii, saw the main entranceway of the elegant Hotel de l'Annapurna blow up, killing three employees. Three more bombs went off—two at palace gates, the other at the National Assembly. "For the next few days there were riot police on every corner of Kathmandu," she remembers. They reportedly jailed about 5,000 suspects nationwide.

Strikes and demonstrations, though rare, had occurred before, notably in 1979, when student-led unrest filled the streets with citizens demanding a greater voice in government. Yet who in this usually most tranquil of nations would have resorted to terrorism? Wedged between two colossal powers—India, with a population 45 times as large as its own, and China, whose population is 60 times as large—Nepal maintains a careful stance of political neutrality.

At the valley's colleges, however, walls blaze with graffiti from half a dozen leftist student groups. Some, with ties to China or the Soviet Union, are active in both the cities and rural areas. But the bombing is widely believed to have been the work of an isolated faction operating out of India. "Down With the Fascist National Assembly!" says one spray-painted slogan.

A former Kathmandu city representative to the assembly is Nani Maiya Dahal, who recently led a strike herself after an overloaded sewage system leaked into the water supply. Brahman women are expected to bathe their husbands' feet each morning and sip the wash water as a sign of respect. Nani Maiya is better known for grabbing state ministers' lapels to make them listen up.

"The king and his people are one in quest of democracy. The problem is corruption among others in government—so much money licking," she tells me as we sit cross-legged on the packed-earth floor of her modest brick quarters in old Asan Tol. "These big improvement projects you read about in the papers, they are not always carried out. If other countries want to help Nepal, they should give aid directly to those who lack the basic necessities, who dare not even drink their own water"—her pounding fist raises dust at her side—"*not* to the politicians and bureaucrats, who line their own pockets!"

But I know of no place where ordinary people are fairer in their dealings or petty street crime less common. The goldsmith I visit in Patan naps in his stall while thousands walk by within grabbing distance of the bright rings and jewels strewn about his smoky forge. Nor does the woman winnowing rice across the way in the Krishna Mandir courtyard worry about leaving her grain overnight among hungry wayfarers.

Lately the looting of antiquities has caused iron grilles to be erected around some images and shrines. A graceful statue of Buddha from the golden age Licchavi dynasty, founded about A.D. 300, was stolen, recovered abroad, and returned to its rightful setting in Chabahil along the old trade route to the northeast. There it was anchored in concrete, then painted to resemble a less valuable modern piece. In no time at all, it was stolen again. Yet this is the hand of international greed; it only emphasizes what treasure lay here unmolested for so long.

"BEFORE, EVERYTHING—whether work or entertainment—was blended with ritual. Everything reinforced the community," 29-year-old Rajendra Shrestha says as we stand

"Chasing the dragon," *a young Kathmandu user heats a piece of unrefined heroin—"brown sugar"—and inhales the fumes. Some 20,000 Nepalese, most of them in the valley, now are addicted to the drug, illegal but cheap and plentiful.*

on a rooftop watching white mountains float above emerald ones. "I don't object to Western ways, just to their blind acceptance by our new generation. It is hard, because the foreigners they see seem to be dripping with dollars. I use the natural love children have for music and rhythm to help them understand the necessity of culture—our culture."

In other words, he teaches kids traditional dance. Which means hand holding and circling. Or so I imagine, until he agrees to perform for a Western audience. And from behind the curtain spins a bodhisattva in a tiger-striped loincloth, a blue face rigid as a mask, crowned, belled, stamping, flashing, yet every blossoming of fingers from a fist controlled, perfectly stylized, retelling an epic tale of fear and salvation. I don't need to ask whether he did devotions beforehand and asked the god to enter with him in the dance; he is transformed, and so are we who behold the dance.

Afterward Rajendra takes no credit for himself but speaks instead of the worthiness of his teachers. It is the traditional way.

The next day I dance out of a taxi's path, spin off a fruit vendor, stamp in a cow pie, look up in despair, and find the toothache god. I'd searched the brick mazes many times for this shrine, never with success. Quickly I borrow a hammer, pound in a coin atop an achingly swollen mass of nails and other coins, and touch my head to it. I don't care if it's the power of suggestion or divine dentistry; my problem tooth is as good as new.

Shrines for every ailment stipple the valley. With uncounted air- and waterborne diseases and just one doctor for every 2,000 people—one for every 300,000 outside the valley—the medical deities are kept fairly busy. Sister Celia, an Indian and a member of Mother Teresa's Missionaries of Charity, leads me into a room full of children: orphans of poverty; offspring of malnutrition and tuberculosis, which so often go hand in gaunt hand.

The older kids feed the younger ones bread soaked in milk. Diapers are being changed, crippled limbs massaged. Since I'm just taking up space, I'm given a newborn infant to quiet. Then I feel a tug and turn around into a pair of eyes—a girl, age five, I guess. Her head sinks into my shoulder, as if we had always sat together this way. "Her name is Yanu," Sister Celia says.

This child was born far to the hilly west. After her mother died, her father mistreated her, and neighbors took her in—until she became too sick to help with chores. Unknown to anyone, she had diabetes. Somehow, she made her way to Patan and lived by begging. By the time she was hospitalized, she could no longer walk.

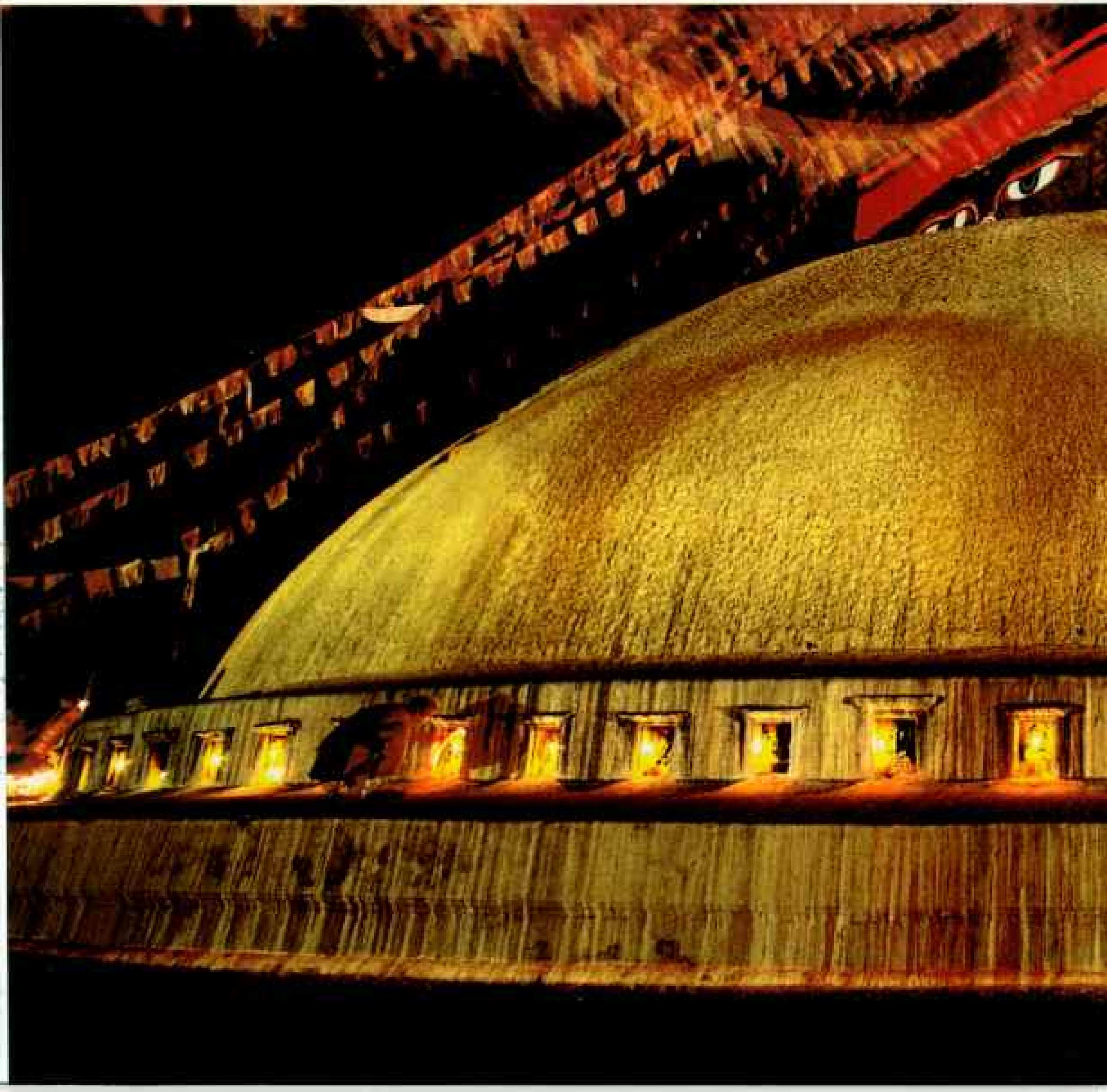
Yanu. She is not five but 15. I should have known from those eyes, and the deer legs of mere tendon on bone. But she is walking again, and of all the things her young-old face shows, the easiest to find now is joy.

THE GODDESS LAKSHMI is coming this joyous November week of Tihar—the festival of lights—through every window and door. She is coming, her way lighted with lamps, to inspect account books and cash boxes, as she has for ages. If she is pleased, she will bestow prosperity for 12 months to come, because Tihar is the Newar New Year—the start of the year 1107. By the Nepalese calendar, the year is 2043 and half over. Confusing for those of us wrapping up A.D. 1986, but you're stepping in and out of centuries a hundred times a day here anyway, and of every 365 days, more than 150 will be festivals.

Across the valley all is being made pleasing for Lakshmi. Houses are cleaned and garlanded, shops repainted. First comes the day to worship the crow, then the dog—those pariah hordes that save the cities from sanitary disaster by living largely on human excrement—then the sacred cow.

Finally it is Mha Puja, the day to worship oneself. "*Namaste*—I salute the god within you." That is the greeting on this day, and every other day in Nepal. Hello. I enter the house of Tirtha Manandhar, who owns Kathmandu's oldest bicycle shop and now sells motorbikes as well. We're soon making mandalas on the floor. With powders and

Coming full circle, *the devout light oil lamps in a ceremony at Bodhnath, a stupa patterned on a mandala design that is a major focus of the Tibetan*



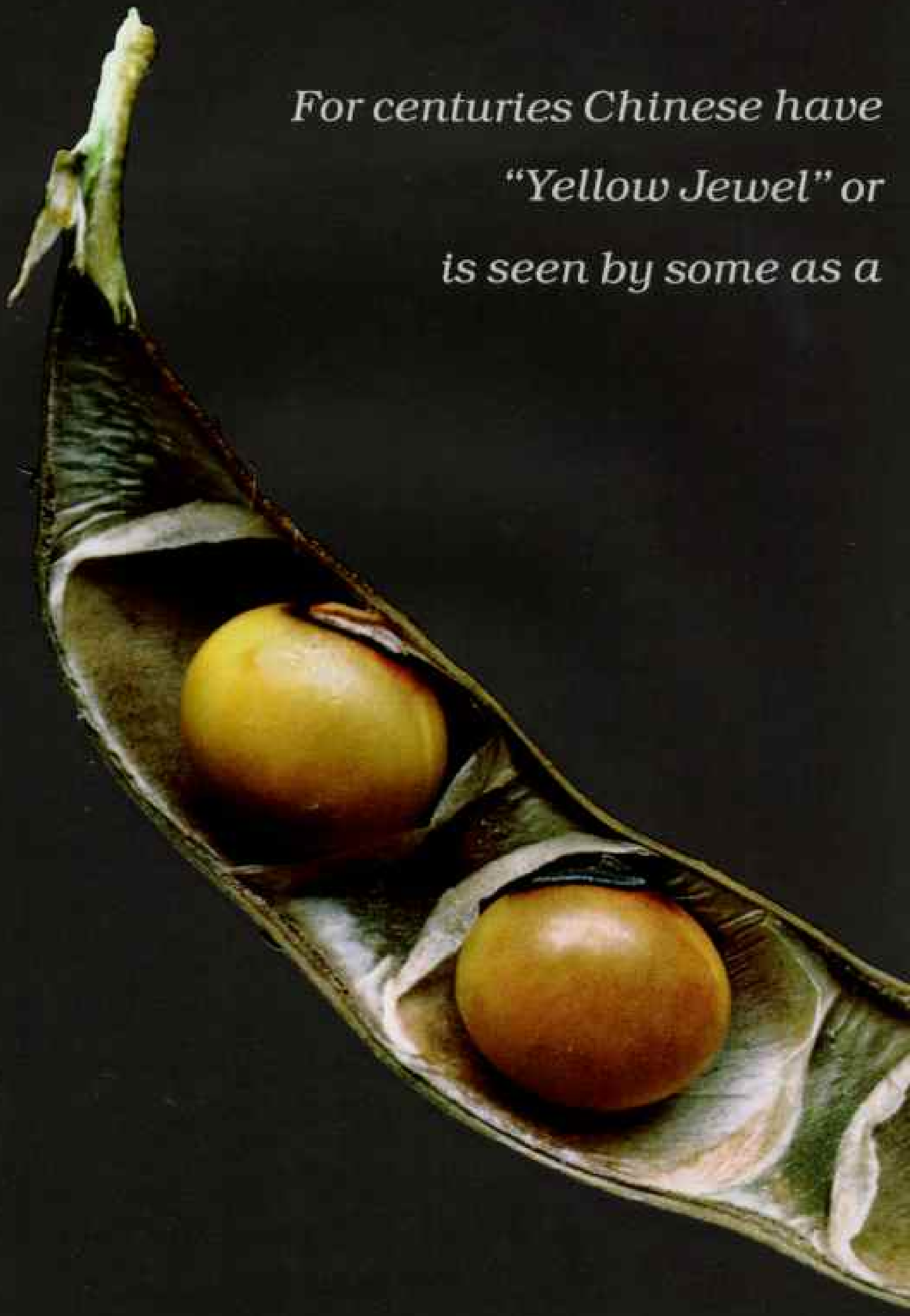
rice grains we draw one sacred circle for each family member, one for me, and one for Yama Raj, king of death, the invisible presence whom I wind up seated next to.

I must perform certain flame-lit ceremonies for death as well as for myself then. But the more familiar you are with something, the less fear it holds for you, and by now I've got the message: no death without life.

Besides, though the ceremonies go on for hours, they are done Nepalese family style—far from hushed. While I'm ritually showered with nuts, fruits, and petals, so, too, fall wisecracks and kids on my lap. And since we're gods, we eat that way, round upon round, washing it all down with the firecracker rice liquor *raksi*. By the time I thank my hosts and start through the cleaned-up, still filthy, always magic streets yet again, my head feels as bright as the sparklers raining down from rooftops, and I sing like the temple guthi members bearing along whole shrines on their litters.

And I promise myself to write this: Nepal is a land where a host of cultures have met, fused, and continued to thrive. This so-called Third World country, facing tough challenges, remains a First World nation of the human spirit, and in the valley at its center, I was made to feel at home. □

community and Buddhist worship. Immigrants restored the old stupa and built new monasteries around it—a sign of the valley's spiritual vitality.



For centuries Chinese have

"Yellow Jewel" or

is seen by some as a

called the Soybean

"Great Treasure." Now this prodigious bean weapon against world hunger.

By FRED HAPGOOD

Photographs by CHRIS JOHNS

Delicately poised between chopsticks, a silky piece of tofu, *made from soybean curds, tests the expertise of a young Japanese geisha-in-training. She must learn to eat this slippery food without touching her artfully painted tips. The soybean was first domesticated in China some 3,000 years ago. A strong-tasting legume that lacks appeal when merely boiled, it can be ingeniously transformed into myriad protein-rich foods.*

Tension mounts at a Harbin free market in northern China as determined shoppers compete for doufu (above). One of the country's most popular foods, doufu (or tofu, as it is now generally known) is often in short supply.

Said to have been invented by a Chinese scholar in 164 B.C., tofu is made by boiling and

crushing the beans, coagulating the resulting soy milk, and pressing the curds.

Today tofu appears in many guises (left), helping to feed the nation's one billion people. It may be fashioned into cakes or loaves, made into candy, or shredded, sliced, deep-fried, steamed, smoked, marinated, or fermented.

THE DAY THE FOREIGNER CAME began as had many others in the lives of the Sun brothers, or, for that matter, in those of their father and grandfather. At three that morning they had let themselves into their one-room *doufu* shop, one of ten that prepared bean curd, the "vegetable meat" made from soybeans, for the villagers of Chao Lang near Shanghai. In the middle of the floor bulked large, dark ceramic jars full of straw-colored beans that had been left soaking overnight. The two brothers ladled the beans into a mechanical crusher, strained the mash, poured the filtrate into an iron pan set in the top of a coal stove, brought it to a boil, ladled it into another jar, and added a coagulant salt.

After an hour, when the coagulant had taken effect, they ladled the thickened fluid into frames draped with cheesecloth, folded the cheesecloth around the material, squeezed whey out of the frames with weights, and opened their shop window. As the villagers began to arrive to buy their daily supplies, beginning at about 6 a.m., they turned the blocks of doufu, one by one, out of their frames and sliced them up into bricks of close to a pound each.

On this particular morning, around ten, the Suns heard a burst of crowd noise, a hubbub of comment and exclamation, moving in their direction. Then a wave of humanity washed into their shop. At its head were the mayor of Chao Lang, an official from the China National Technical Import Corporation, and a foreign dignitary of some sort, a Westerner, who began pestering them with one question after another. When did they get up? What did they do first?

Behind this party of visitors the citizens of Chao Lang gathered in concentric generations. The youngest and boldest crowded right into the shop and stood among the visitors, staring up at them and smiling brilliantly. Behind them, in the door and spilling out into the street, were the teenagers, and peering over their heads, the parents and grandparents. Back inside the shop the foreigner was still grilling the Suns. "So how long have you been making bean curd?" he asked.

How long? Sun Qing-fu stared thoughtfully at the questioner. A long time, he said, shaking his head. Then he broke into laughter. Yes, indeed. A *very* long time. Then the children, who had been following the questions and answers relayed by the interpreter, started laughing themselves. "What did the foreign guest say?" the teenagers asked. "He asked how long we've been making doufu!" And then the teenagers laughed, and passed the remark to the next generation behind. There must have been dozens of villagers outside, for those inside could hear laughter spreading up and down the streets of Chao Lang for minutes afterward.

Doufu, the Chinese name for *(Continued on page 75)*

Fred Hapgood is a Bostonian whose writings often describe the connections between science and ordinary life. Photographer **Chris Johns** has covered tornadoes, Alaskan glaciers, Canada's Fraser River, and the Dust Bowl in earlier GEOGRAPHIC articles.

Bean's MARKET

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9 Lives

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ONE-RAM ALKYD

HEALTHY BAKED MUFFINS 50¢

National Geographics 3 for $1

Invisible ingredient in countless products, the soybean plays an amazingly pervasive role in everyday life. Artist James Gurney included more than 60 soybean-related products in this painting, done in the style of Norman Rockwell. He not only called on neighbors and friends for models, but also portrayed himself and his wife emerging from the store, startled by a skateboarding boy carrying a cone of tofu "ice cream"; the boy's shorts—like the tablecloth—bear a bean-pod motif.

The bags the couple carry, the store-window and sidewalk displays are replete with items that have a soybean connection.

Cardboard, glues, and animal and human foods are commonplace soybean products. The sidewalk customer's caulking, paint, wallpaper, gasoline, and the muffin he buys all owe a debt to soy—as does the bicycle tire.

The beer sign reflects the use of soy meal in the brewing process. The fire extinguisher uses soy protein in its foam. And pre-1981 NATIONAL GEOGRAPHICS were printed on soy-lecithin-lubricated presses. The car symbolizes an experimental one built with soybean plastic by Henry Ford. The artist's final tribute: He used soy-based paint.

"*Gold from the soil" to American farmers, the hardy annual soybean plant (below) stands about two feet tall, bearing its seeds in fuzzy pods clustered near the stalk. Superior in protein content to any other legume, the soybean is central to the diet of hundreds of millions of East Asians, with more than half the world's supply coming from the United States. In Illinois—*

the largest soybean-producing state—combines cruise the fields (left), helping to harvest the nation's lucrative annual crop of some two billion bushels.

"ATLANTIS" PROJECTION, COURTESY JOHN BARTHOLOMEW & SON LTD., EDINBURGH

Soybean trade

Some 220 years ago a former seaman named Samuel Bowen brought soybeans from China to a Savannah, Georgia, plantation. Today North and South America produce more than three-quarters of all the soybeans grown in the world. In the Orient, China remains the major producer. Japan, with room to grow just .25 percent of the world's supply, imports more soybeans than any other country.

In the Orient most soybeans are consumed directly as food, whereas in the West most are used as animal feed and in a variety of industrial and food products.

Western Europe grows few soybeans but is a leading importer. Most beans are processed into meal and oil, which are counted as additional consumption, thus accounting for the disparity in import and total soybean supply figures.

AUSTRALIA

Pacific Ocean

OCEANIA AND SOUTHEAST ASIA

Indian Ocean

JAPAN

TAIWAN

KOREA

CHINA

SOUTH ASIA

CANADA

UNITED STATES

WESTERN EUROPE

U.S.S.R. AND EASTERN EUROPE

MIDDLE EAST

MEXICO

CENTRAL AMERICA AND CARIBBEAN

SOUTH AMERICA

BRAZIL

ARGENTINA

AFRICA

EQUATOR

Atlantic Ocean

	Exports	Domestic use
United States	24.9	50.2
Canada	0.9	0.9
Western Europe	1.5	32.5
U.S.S.R. and Eastern Europe	0.2	0.2
China	1.4	10.0
Japan	0.3	4.1
Taiwan	0.6	0.9
Oceania and Southeast Asia	1.3	0.9
Brazil and Argentina	16.5	21.4
Mexico	0.5	1.1
Central America and Caribbean	1.0	0.7

Soybean product supply

Exports

Domestic use

Major growing area

Soybean product use
(Pounds per capita annually)

250-736

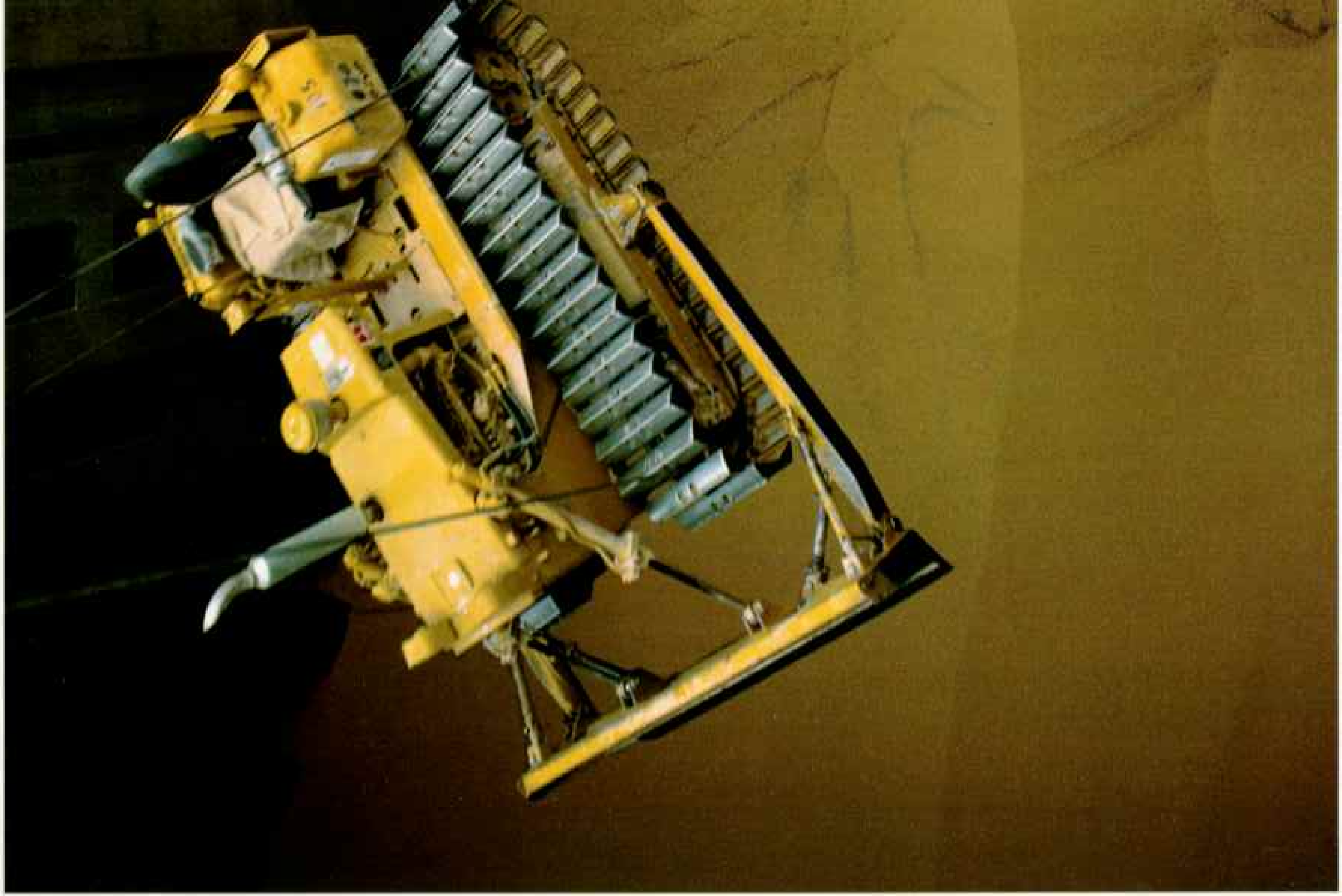
76-249

28-75

0-27

Arrows show trade-flow volumes for soybean seed, meal, and oil. Arrow and bar numbers are in million metric tons, 1984.

NGS CARTOGRAPHIC DIVISION : DESIGN: NANCY SCHWEICKART; RESEARCH: MICHAEL A. NICOLS, LISA R. RITTER; PRODUCTION: ELLEN J. LANDEMAN; MAP EDITOR: SUE PLATIS SOURCE: UNITED STATES DEPARTMENT OF AGRICULTURE



(Continued from page 69) bean curd, has been made in China, where it was invented, for about 2,000 years. It is the most important of the foods prepared in the East from the soybean, that remarkable vegetable that not only allows the Chinese to feed a quarter of the world's population on a tenth of its arable land, but is also a rock on which the Western diet is built and a major hope for averting world famine.

I HAD TRAVELED to China in part because the whole story began here, at least 3,000 years ago, when farmers in the eastern half of northern China started planting the black or brown seeds of a wild recumbent vine. Why they did this is unclear; plants that lie on the ground are hard to cultivate, and the seeds of the wild soybean are tiny, hard, and, unless properly prepared, indigestible. Whatever the reason, the farmers persevered, and evidence suggests that by 1100 B.C. the soybean had been taught to grow straight up and bear larger, more useful seeds. These changes were sufficient to add the bean to the list of domesticated plants.

The new crop arrived at the right time. The bean is wonderfully abundant in protein of the highest quality, and, within limits, grows well in soils too depleted to support other crops. The soybean plant supports colonies of microorganisms that return rent in the form of soil-enriching nitrogen; this was an important point in a civilization that had been farming many of the same fields for thousands of years. The enthusiasm farmers had for their new crop is suggested by some of the names given different varieties: Great Treasure, Brings Happiness, Yellow Jewel, Heaven's Bird.

Over the next several hundred years the soybean spread from its center of domestication to become a staple of the Chinese people. As it did, the third virtue of the bean (together with high food value and ease of

Full of beans, a U. S. cargo ship in Yokohama, Japan, awaits unloading. The lowered tractor will feed the soybeans into huge suction nozzles. Almost half the U. S. harvest is sold overseas.

production) appeared—a magic versatility. Dozens of different forms of food were developed from it, of which the most important were soybean sprouts, steamed green beans, roasted soy nuts, soy milk, soy sauce, *miso* (a fermented soybean paste), soybean oil, *tempeh* (a fermented soybean cake apparently invented in Indonesia), soy flour, and of course doufu, which is the basis for dozens of other soy foods.

I LEARNED ALL THIS later, long after I had returned from amusing the people of Chao Lang. At one point during my education, a citizen of Shanghai, an English teacher named Johnny Tong, explained what had happened. "The Chinese consider doufu very common," he said. "Valued, but common. For instance, in our stories a bean curd seller is always a poor man with a good heart. We refer to a girl who is beautiful but poor as *doufu-xishi*, 'a bean curd beauty.' When a man is treating a woman cheaply, taking her for granted, we say he is just 'eating her doufu.'" What amused the villagers, he suggested, was that I seemed all agog over doufu, as if it were some sort of high-tech breakthrough.

As we talked, walking through the corridors of plane trees that line the streets of Shanghai, we would pass through the outdoor markets where, under the new economic policies of China, individuals were allowed to sell products of their own manufacture. Sometimes we would see a doufu seller, back on the streets after all these years, and stop to chat. "How's business?" I would ask. "Terrible," I would hear. "I have to stand here all day. Who can compete with the state stores?" (The state stores sold a cheaper, but less tasty, version.) But Tong, after some calculations, advised me that the sellers were doing very well indeed.

In the last half of the first millennium A.D., the Japanese upper classes became slavish Sinophiles and imported many aspects of Chinese culture—writing characters, law codes, political institutions, and, perhaps most important, Buddhism. Doufu, called *tofu* in Japan—and now elsewhere—arrived as one of the things associated with the new religion. (By this time the soybean itself had been cultivated in Japan for several hundred years.)

Buddhist monks are strict vegetarians, and doufu had become an important food in Chinese monasteries. For several centuries Buddhism was an upper-class religion in Japan; these social associations pushed the development of tofu and its associated soy foods in a different direction than in China.

The Chinese have developed dozens of different ways of reprocessing doufu, most of which change the texture and/or the taste of the food radically. They press, shred, slice and marinate, steam, smoke, deep-fry, ferment, and salt-dry it, often combining more than one process on this list.

In general, Japanese cuisine preserves the simplicity of tofu, its subtle taste, custardy texture, and "dazzling white robes," in the phrase of a sixth-century monk, in dishes of awe-inspiring elegance. The Japanese do some processing: Dried-frozen tofu, spongy and highly flavor-absorbent, is a favorite. Tofu is simmered with meat, vegetables, and noodles in *sukiyaki*. Still, the difference in emphasis is unmistakable.

In Kyoto I asked restaurant manager Taku Watabe about Japanese cooking and soy foods. "The summers are very hot here," he said, embarking on an apparently unrelated subject, "and very humid. Our winters are bitter. In the eighth century our poets considered the meaning of these extremes and counseled acceptance; to open oneself to nature and let it pervade your life."

In February Watabe might serve *ozumi-dofu*, a cube of tofu mantled in a bed of rice. Not all the ways of eating tofu relate to the seasons, Watabe said, but many do.

PERHAPS THE MOST DRAMATIC illustration I found of Watabe's point was encountered in the Yachiyo Honten restaurant near Nagoya. Yachiyo Honten lies in Okazaki Park, on the grounds of the castle in which Tokugawa Ieyasu, the famous shogun who unified Japan, was born. The restaurant itself sits on a corner defined by a bend in the moat that once girdled the castle. Someone entering one of the small dining rooms and rolling back the wide wall screens will find himself floating eye to eye with the crowns of the maples, oaks, and alders that now grow out of the moat. And if he visits on a brilliant afternoon in October, as I did, the light

flooding into the room will seem to buoy it up like a balloon and send it soaring through the color bursts of autumn foliage.

The chef, Teiichi Nakagawa, is a young man with a broad experience of the world; he has eaten at, and was unimpressed by, Maxim's in Paris. "Art is limited," he began, in a tone that made it clear that he was making no idle observation but reciting the core of his faith as a cook, "but the taste of nature is unlimited. No matter how a dish is prepared, if it is served and eaten often enough, it will no longer convey nature's taste. The preparation of food changes so as to keep people open to the taste of nature."

He then brought in a dish composed of pieces of tofu that had been cut to a thickness of about one-third of an inch. Sheets of seaweeds of different colors—blood orange, golden brown—had been pressed on the tofu tiles, which were then cut to the shapes of maple and sycamore leaves. Finally, these were arranged over a pile of silver fibers pulled from a Chinese radish, which were teased up through the tofu forms. The effect achieved was that of a heap of autumn leaves that had been raked casually into a pile and set on fire.

The first public notice of the arrival of

Glowing like liquid gold, soy oil, which is heated during the refining process, is the world's most plentiful vegetable oil. Fermenting soybeans and wheat are checked at Wisconsin's Kikkoman Foods (below), producers of seven million gallons of soy sauce annually.

soybeans in the West was made by the great Swedish biologist Carolus Linnaeus, who in 1737 included them in an inventory of plants grown in a garden in Holland. They were introduced to the New World by Samuel Bowen, a merchant who brought seeds back from China in 1765. For the next century the soybean was little more than a botanical curiosity. Then, in the 1880s, French scientists reported that soybeans, unlike other beans, contain virtually no starch, from which the body manufactures sugar, and recommended they be used in diabetic diets.

This was the first of a series of discoveries made by the new profession of nutrition as it examined and analyzed *Glycine max*, the soybean. A second came 20 years later, when the importance of proteins began to be understood: Amazingly, the soybean was found to have an even higher protein content than lean beef.

OVER the next several decades nutritionists explored such things as digestibility, amino acids, vitamin and mineral intake, alkaline-acidic balance, allergenicity, salt, fat, cholesterol, metabolic waste products, and hormones and antibiotics. Each time a new issue arose, someone would check how the soybean rated, and time and again the bean would be shown to do very well compared with other foods. However, as impressive as these discoveries might have been to nutritionists, they triggered no great consumer demand in the West.

Ironically, this rejection presaged one of the more dramatic chapters in the history of the bean, as I found out in Lauderdale County in southwest Tennessee, part of one of the most productive soybean farmlands in the world. There I met Page Box, Jr., a former president of the Tennessee Soybean Association. Soybeans are not a new crop in Lauderdale County, he told me. For decades farmers had grown the bean for fodder, harvesting the whole plant, letting it dry, and then feeding it to their livestock. But after World War II everything changed. Box suggested we drive over and meet a gentleman named Fullen, who had stood as close as anyone to what happened then.

The land we drove through was as flat as an airport apron. It seemed only about three inches higher than the Mississippi River; flooding, Box said, was a constant threat. About half of the bare handful of houses we passed were raised on thick stilts, and from a

HENRY FORD MUSEUM, DEARBORN, MICHIGAN

Tireless in his pursuit of unorthodox uses for his favorite legume, Henry Ford startled journalists on November 2, 1940, by wielding an ax against a trunk lid made from a highly resilient soybean-derived plastic.

The enormous genetic variation within the same species is seen in part of the collection of 7,359 soybeans at the University of Illinois at Urbana-Champaign (facing page).

distance they seemed to be walking across the fields. "Last big flood we had," Box said, driving into the Fullens' place, "I came down here in my boat, tied up to the porch, and stepped right out." The porch was a good five feet off the ground.

Jim Fullen and his sons, Steve and Jimmy, farmed about 5,000 acres of soybeans in partnership with Box. Our meeting had a somber mood. The price of soybeans in relation to the cost of production was way down, and soybean farmers were under serious financial pressure. Many—one estimate I heard was one-third—were not expected to make it, though the Fullens themselves thought that *they* would.

"The glamour's gone from the Cinderella crop," Jimmy Fullen said, looking out his window. "The Cinderella crop?" I asked.

FORTY YEARS AGO, I was told, the major crop in Lauderdale County was cotton, though a lot of corn and other vegetables were grown as well. A fair amount of livestock was raised, and there was a good lumber industry. Soybeans were attended to only when the cash crops had been taken care of.

After the Second World War two things changed. Historically, China had been the major supplier of soybeans to the world market. However, the course of postwar politics and the difficulties experienced by the Chinese in recovering from wartime devastation prevented the restoration of prewar trade relations with the West. The world soybean market needed a new source of supply, and the American farmer successfully stepped into the position.

Second, and far more important, postwar affluence sent the developed world on a binge of meat eating. By 1973 per capita consumption of chicken had increased by factors of 2, 4, and 15 in the U. S., Europe, and Japan respectively. Supplies of the traditional source of protein in livestock feed—fish meal and scraps from meat-processing plants—were inadequate to meet these increases in demand. The high food value of the soybean made it a natural candidate. The bean was tested and with a few modifications and supplements met the need perfectly, not only for chickens and hogs, but also for animals as diverse as mink, foxes, shrimp, catfish, eels, trout, bears (in zoos), and even bees and silkworms.

Between 1945 and 1985, as the effects of these changes were felt, the U. S. soybean harvest increased in volume 11 times. The bean became the farmer's most important cash crop and the country's leading agricultural export—in 1985 the United States exported 3.7 billion dollars' worth of soybeans.

This was why it was called the Cinderella crop. A poor relation that had always been given the leftovers in land and time had become "gold from the soil." Further—the Fullens stressed this point—because it had

been such an unimportant crop during the New Deal, there were no acreage restrictions on the bean, as there were on cotton and corn. Every farmer could plant as much of it as he liked. Livestock was cleared out, pastures plowed under, and acreage switched away from cotton and corn.

Soybean agriculture is not that different from that of other commodities, the Fullens said, but there are some differences. As soybean acreage grew, those differences became more important. For one, soybean agriculture is less labor-intensive than other crops, especially cotton. The bean is less

Making his early morning rounds, Hiroji Kiyokawa delivers tofu door-to-door in Kyoto. He and his family make fresh tofu daily in their shop, one of 25,000 in Japan. Such small businesses are threatened, however, by the advent of cheaper, mass-produced tofu now sold in supermarkets.

finicky both to grow and handle, which means that more of the agricultural labor can be done by machine. At the time—the 1950s and '60s—this was just one more reason to make the switch, since farm labor was getting scarce anyway.

But the Fullens, as do other farmers I spoke to, believe that at some time cause and effect changed places, and that the switch to the bean itself helped depopulate the region. Earlier a farmer named M. C. Bevis had told me flatly: "Soybeans changed the structure of the population down here. And the life-style." And now, Jimmy Fullen added, "It's deserted compared to the way it was when cotton was here."

The ease with which the soybean grew on marginal ground meant that every acre could be devoted to it. "Every turnrow, every tree, every bush was pushed out," Steve Fullen said. The oak trees went down. "I cleared 10,000 acres myself," Jim Fullen added. "Soybeans made this county, so far as the land goes." Planting ground that used to be covered by trees and bush and pasture was remunerative then, but it carried a hidden cost, in that there were fewer roots to hold down the soil. Farmers were told by soil engineers that 40 tons of topsoil an acre was being washed into the Mississippi every year. "This is the most eroded county in the state right here," Steve said. "But I don't see what can be done about it," his brother added. "Farmers don't have the money to put those safeguards back in."

In the early 1980s the price of the dollar rose dramatically. Since a foreigner wishing to buy from an American producer has to pay in dollars, this indirectly increased the price of the soybean in foreign markets, which had been buying half the harvest. At the same time, large new competitors, especially in South America (Brazil now earns nearly as much from soybeans as from coffee), started to appear.

These developments depressed soybean

Hanging up to dry, translucent sheets of yuba (above) are made by skimming heated soy milk. Tissue thin, the silky Japanese delicacy is rolled and sliced, then eaten in soup or served as an appetizer. In northern Japan, Ume Murata (right) alternately freezes and thaws tofu to make spongy, dried-frozen squares.

prices perilously close to cost—below cost, in the case of many American farmers. Most people I spoke to thought the result would be that the number of people living and working on the land would decline still further.

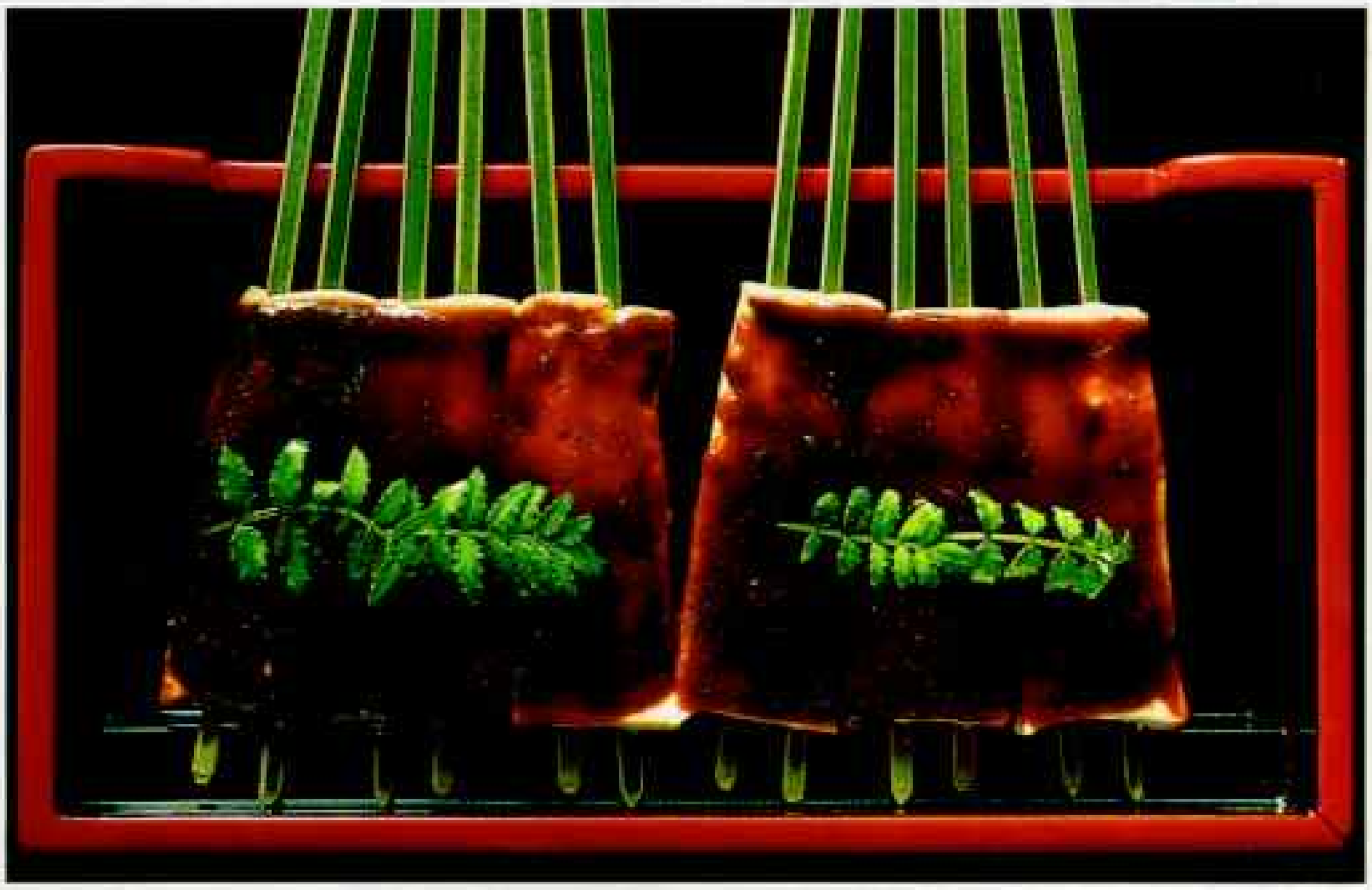
Once a soybean graduates from the farm, it is almost always taken to a processing plant, where its oil is removed. (The natural soybean tends to make livestock a little flabby.) The extracted oil—far more than most of us imagine—is turned into foods such as margarine, mayonnaise, shortening, and salad dressings. Virtually all of the oils and fats used in prepared dressings is soy oil, as is 83 percent of that used in margarine, 80 percent of that used in salad and cooking oils, and 62 percent of that in shortening. The average American consumes almost six gallons of soy oil a year, or 40 percent of total annual fat and oil intake.

Meanwhile the rest of the bean is shipped off to feedlots and poultry producers to feed animals that themselves will eventually end up in supermarkets. Thus over the last 30 years the soybean has become as important to the Western diet as to that of the East. If some virus were to kill off the world crop, the peoples of both hemispheres would find their diet drastically altered. The only difference is that in the West the bean is invisible. Even pure soy oil is usually sold as "vegetable oil."

For the last few decades this obliviousness to the value of the soybean has irritated and stimulated a number of crusaders, bean activists who see it as *the* solution to some critical human problem. Perhaps the most famous was Henry Ford, who believed that the future of the country depended on farmers' becoming producers of industrial goods, and that the soybean was ideal for this partnership. At one point he said his goal was to "grow cars rather than mine them." Ford tried to make a dent in the general public indifference with a number of public relations spectacles, in the most famous of which he

A feast for the eyes

Japanese dishes show the soybean in its most artful incarnations.



Elegantly simple, "simmering tofu," or yudofu (left), is cooked in a wooden casket and served with a teapot of soy sauce. Decorated with tiny leaves, dengaku (above) is made by broiling skewered tofu coated in miso (fermented soybean paste).

The first and tastiest skimming of soy milk produced these mouth-watering strips of yuba (center). A trio of miso-flavored dumplings is served on a smooth rock (right).

attacked an auto body made of soybean-based plastic with an ax to demonstrate its resilience (page 79).

Ford's dream might seem stranger now than it did then. In his day, in the U. S., the soybean was not a food but an industrial commodity. Soybean oil was used to make glycerine, soft soaps, paint, linoleum, varnishes, enamel, waterproof goods, oilcloth, rubber substitutes, artificial petroleum, and ink. Soybean meal was used as a low-cost plywood adhesive. At Ford's direction the laboratories of the Ford Motor Company discovered several more industrial uses for the soybean. By 1935 Ford was squeezing a full bushel of beans into the manufacture of each Ford car. But after the war, petroleum derivatives successfully invaded most of those markets, and today only a tiny fraction of the soybean crop goes to industry.

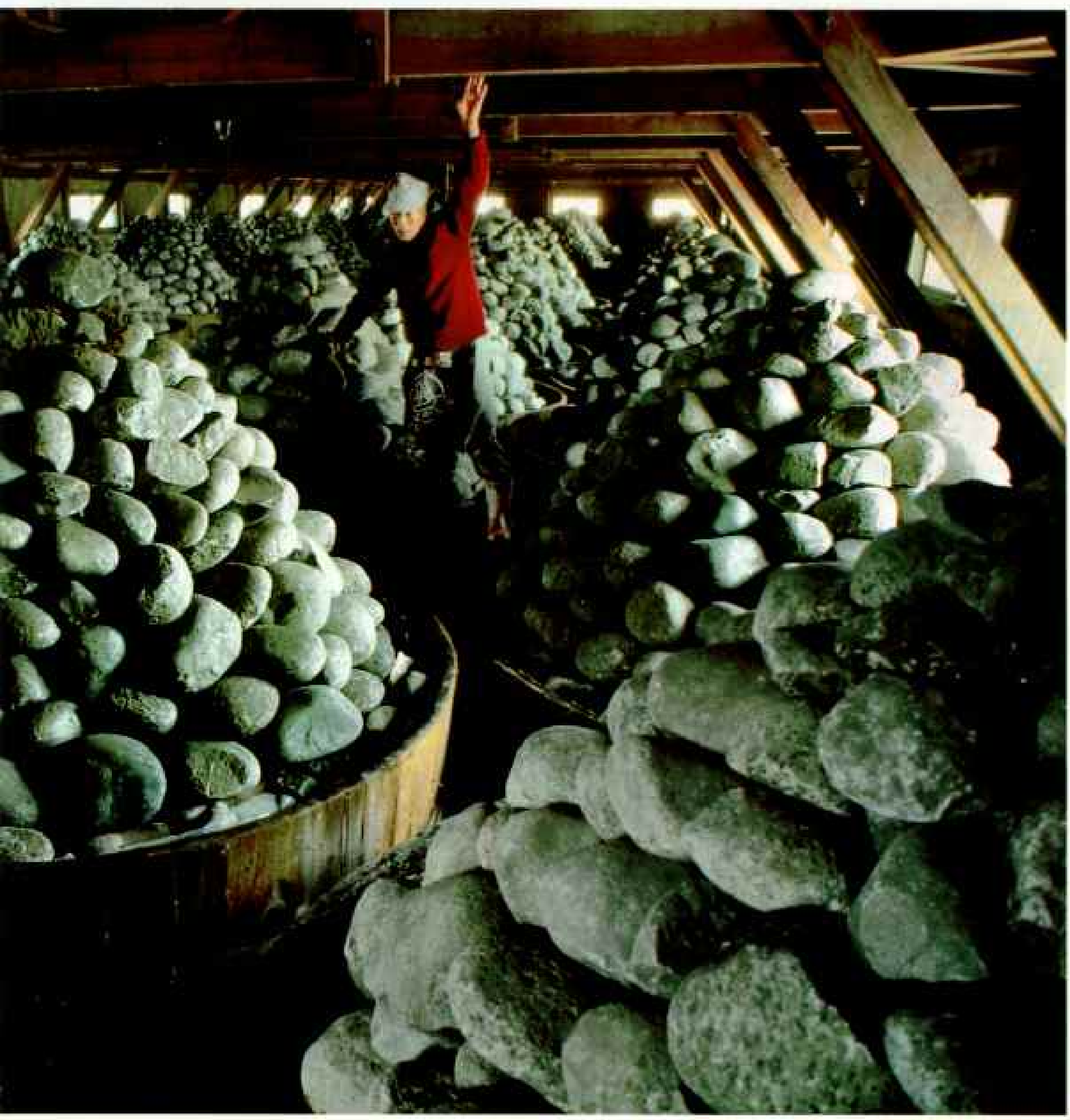
WILLIAM SHURTLEFF and his wife, Akiko, stand in this innovative tradition, although they are concerned with a different problem. In 1976 they founded the Soyfoods Center in Lafayette, California, in the belief that beneath the news stories of famines and relief efforts lay a more sinister problem: a general deterioration in the diet of the peoples of the underdeveloped world, especially in protein. "Many believe that worldwide agricultural output has failed to keep pace with the increase in population," Shurtleff says. "This is not true. The real problem has been the postwar transition, all across the West, to a meat-centered diet.

"During the war, meat was in short supply, even in this country, and the government promoted the soybean as a substitute, touting its high protein content and low cost. But after the war, interest in soy foods dropped off, apparently because people continued to identify them with wartime deprivation and the government's emphasis on good nutrition. The American public went back to eating meat."

But animals are very inefficient processors of protein, he explained. To grow enough chicken meat to make up the minimum daily protein requirement for one human, those chickens must first have been given enough protein in their feed to satisfy the minimum requirement for six people. With beef it's the minimum requirement for 15 people.

Shurtleff, a tall man, whippy as a blackboard pointer, talks glowingly of what he sees as a swing to soy foods by a new, postwar, generation: Tofu and miso are in more and more supermarkets; tempeh sales are up 33 percent. One hundred and fifty new tofu plants have been started in the U. S. since 1975. The most successful soy food ever introduced in the West has been tofu "ice cream," which has grown more than 600 percent in sales over the past two years. (By the summer of 1986 there were 45 brands on the market.)

Ankle-deep in a vat of cooked soybeans, Masao Kato (left) prepares labor-intensive Hatcho Miso, the emperor's favorite. Made by only a few companies in Japan, this soybean-paste specialty ferments for 18 months in aged cedar barrels, compressed under the weight of carefully stacked stones (below).



It was easy, listening to these impressive statistics, to forget that the per capita consumption of tofu and other soy foods in the United States is still less than one percent that of meat.

DIRECTLY or indirectly, the soybean has become central to the diets of both the East and West. For instance, soy milk, the liquid left after beans have been crushed in hot water and strained, is a widely consumed beverage in the East (it's as popular as Coca-Cola in Hong Kong).

But the most important remaining question concerns the soybean's potential to feed the peoples of the Third World. In the mid-1970s a team of nutritionists from the United Nations launched a test case when they found, in a survey of Sri Lanka, that as many as half of the children were suffering from some degree of protein deficiency. The government decided to remedy this condition by introducing soya, as it calls soybeans, into the national diet.

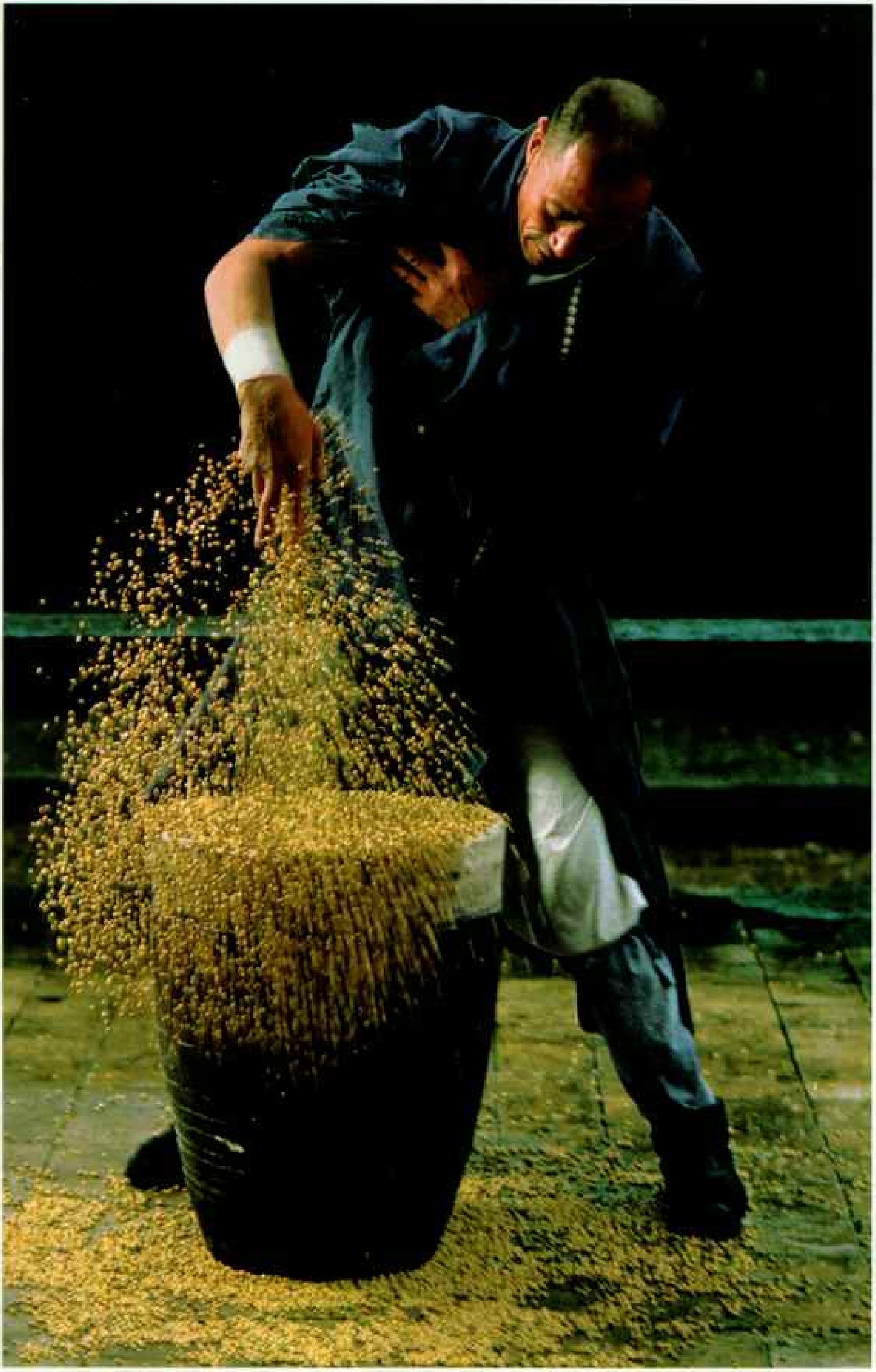
This was no simple endeavor. Foreign-currency restrictions prevented Sri Lanka from just importing a lot of finished soy foods. "We had to organize an entire industry right across the board," Dr. H.M.E. Herath, deputy director of horticulture, said, "from growing the seed to recipe preparation." Further, the soybean is native to the temperate zone, and most of the techniques developed for its utilization, from agriculture through storage and processing to food preparation, assume a cooler, drier climate. And last, virtually no one in Sri Lanka had ever seen soybeans or soy foods before. Everything had to be learned from scratch.

The first step, said Dr. M.H.J.P. Fernando, deputy director of agriculture for research, was to find which of the thousands of varieties of soybeans grew best under tropical conditions. The Sri Lankans received expertise from the International Soybean Program at the University of Illinois, an organization set up to help Third World countries adapt the soybean to their needs.

"One of the government's ideas of how to use soya was to mix it with existing foods," Dr. Herath said. "Make it an invisible additive, so no one would know it was there. We launched a campaign to fortify all the flour

Food for the soul as well as the body, the soybean in Japan plays an important spiritual role. Dignitaries in Tokyo throw packets of sacred soybeans (above) to eager hands during mame-maki, *a ceremony held each February when winter gives way to spring. At this time beans are also scattered at home to ward off evil and welcome the Japanese new year.*

At an altar in Tokyo (right) a woman gives her broken sewing needles a final resting-place in a soft bed of tofu during a ceremony called hari-kuyo.



milled in the country with 5 percent soy flour. This was one of our biggest plans." Unfortunately, Sri Lanka's largest mill refused to participate in the program.

The staff of the island nation's Soyabean Foods Research Centre regrouped and developed another plan—to persuade citizens to substitute soya for an existing food. In this case they hoped to substitute it for coconut milk, which is widely used as a cooking medium. "Coconuts are a land-intensive and unpredictable crop," said S. Pathiravitana, editor of *Soyanews*. "The government hoped to wean the people from dependence on them while also improving their diets."

A factory was built to produce a soy-milk powder, to be marketed as Rajasoya. A promotion campaign was planned—and then, as if the gods themselves were rooting for the cause, at the very moment of the product rollout, the coconut crop collapsed.

"The price of a coconut went up from one rupee to five," Cecil Dharmasena, director of the research center, recalled. "Rajasoya was very successful. Everybody started using it. The factory hired a second shift and began planning a third. Then coconut prices began to slip; they went down to two and a half rupees, and back up to three—still a lot more expensive than they had been, but suddenly people just started paying the higher prices. Sales of Rajasoya plummeted. We went to one shift, two days a week."

There are Sri Lankans, I was told, who prefer soy-milk powder to coconut milk, finding the latter too heavy and greasy, but obviously they are a minority. The research center subsequently developed coconut-soy blends that native Sri Lankans (taste tests seem to show) find more acceptable, but so far no entrepreneurs have been willing to back them in the marketplace.

The campaign to win the hearts and minds of Sri Lankans for the soybean continues. The Rajasoya factory is again working near full capacity, and the government is planning to supply schoolchildren with a fresh soy beverage every day. One Muslim trader I spoke to waved away the idea that the soybean had failed in Sri Lanka. There were still lots of possibilities, he said. "This is a Buddhist country," he reminded me. "We eat meat, but we feel guilty about it."

ANOTHER REASON why soya might yet succeed in Sri Lanka, at least over the long term, is that the local farmers continue to grow the bean, and in increasing volume. "Who buys your beans? The government?" I asked the farmers. No, I was told, private traders. "And who do they sell them to?" Nobody seemed to know, so, together with Pathiravitana, I visited the Pettah on Old Moor Street in Colombo, headquarters to the traders of Sri Lanka.

There, away from the noisy, colorful circus that is the traffic of downtown Colombo, we went from stall to stall, and soon the source of this mysterious increase in demand became clear: Poultry growers were buying the bean. The livestock industry had arrived in Sri Lanka, and it was thriving. "The old ways are certainly breaking down," sighed Pathiravitana, referring to the Buddhist strictures against eating flesh. For myself, I was struck at finding a case in which livestock feed was apparently playing a positive role in the development of soy foods by stabilizing the market for the farmer while the soy-foods industry experimented with different approaches for human comestibles.

Spurred to greater efforts by initial setbacks in Sri Lanka's soybean campaign, researchers have come up with a variety of soy products, including a coffee "extender," breakfast cereal-like soybean flakes, and increasingly popular vegetarian "Soyameat," devoid of the characteristic legume taste that marked—and doomed—earlier substitutes. The experts now cite Sri Lanka's program as a model for other developing nations, noting that consumption of the nutritious, all-purpose bean has significantly increased in the past five years.

And that's not just chicken feed. □

The mighty soybean challenges a martial-arts master: Shi Yong-shou, 56, a former Shaolin temple monk in China's Henan Province, tests his strength by plunging an arm elbow-deep into the bean-packed barrel.

They Stopped the Sea

By HANS VAN DUIVENDIJK

Photographs by PABLO BARTHOLOMEW
GAMMA-LIAISON

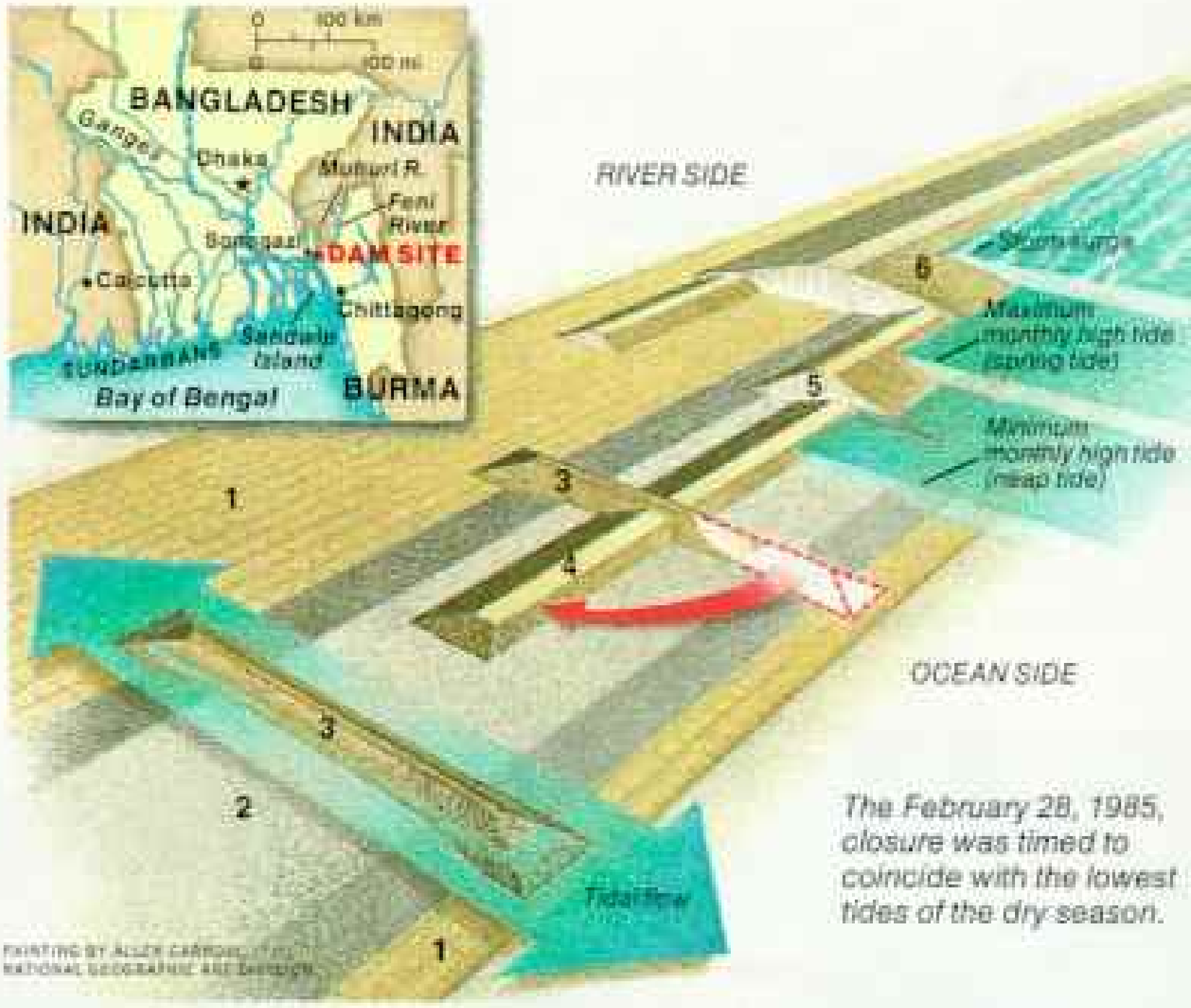
A tide of human muscle dikes a river

Lacking money and machinery but rich in manpower, Bangladesh used the brawn of 15,000 men to close the mouth of the Feni River to control flooding and create a freshwater reservoir for irrigating rice. Crossing the muddy river bottom at low tide, workers carry 45-kilogram (100-pound) bags to 11 stockpiles. During a frenetic seven-hour intertidal marathon, they blocked a 1,300-meter (0.8-mile) gap, the largest dam yet built in the south Asian country.

AN AREA no larger than Wisconsin, Bangladesh has struggled since independence in 1971 to feed its people, now numbering 107 million. It is one of the world's most densely populated nations. For years the country—as flat and riverine as the Netherlands—has constructed earthen levees across tidal creeks to protect flood-prone cropland. Usually the dams are built out from each bank by filling compartments with palm leaves, brush, and clay. The narrowed gap, where the tide rushes at ever increasing velocity, must be sealed within one intertidal period. But sometimes the force of the tide scours out the bottom, destroying the partial dike.

For the closure of the Feni in 1985, I, as consulting engineer with the Dutch firm of Haskoning, drew on a decade of experience in adapting old-time Dutch methods to the Bangladesh circumstance.

Construction began with the sinking of huge mattresses (*diagram*, **1**) to protect the river bottom from erosion. Boulders and clay bags were dumped in gullies to make a level sill (**2**). Over this base more bags were stockpiled (**3**) until closure day. Then teams hoisted bags into the gaps (red arrow), creating the barricade (**4**). Next earthmovers raised the dam's height (**5**) with clay. The structure was faced with concrete and bricks (**6**).



The February 28, 1985, closure was timed to coincide with the lowest tides of the dry season.

A supervisor for the general contractor, Japan's Shimizu Construction Co. Ltd., led warm-up exercises (***below***) to instill a sense of teamwork.

Many workers like this Bengali (***left***) protected their heads with sacks against the dripping bags of clay; they earned five takas (20 U. S. cents) for each bag carried. Some men proudly lifted two at a time.

ON THE DAY before closure the four-meter-high stockpiles, each containing 100,000 clay-filled bags, were inspected for the last time. As the tide rose and turbulence increased, these fishing boats provided men with a lift to shore.

The sea, rising two meters (6.6 feet) in half an hour, rushed through the gaps at 2.5 meters a second. The current could have dislodged the bags, undercut the artificial islands, and destroyed six months' work. But the islands held.

Early the next morning a thousand-man team was directed to each artificial island, identified by a colored flag. The laborers were particularly eager since they would earn 100 takas for the day, plus a 10-taka bonus to members of the team that finished first.

As the tide reached its lowest point, the workmen began to shift the top layers of bags into the gaps alongside the stockpiles. This method of closing a river was employed in the Netherlands as recently as 1953.

The Bangladesh closure is crucial to the area's Muhuri Irrigation Project, which bears the name of an important tributary of the Feni River. The

project, sponsored by the World Bank, the European Economic Community, Canada, and Bangladesh, includes a 1,200-hectare (3,000-acre) reservoir, a sluice, and canals and pumps for irrigating 27,000 hectares.

Almost everything was done by hand. Clay was dug in the Chittagong Hill Tracts, trucked down, and scooped into jute bags at riverside. We could not use the sand from the river because it was so fine that it sifted out of the bags.

Twelve million bricks were baked in kilns near the work camp; then men pounded most of the bricks apart to make gravel and aggregate needed in the final concrete facing. Even with the use of local labor and resources, the entire 3,000-meter-long structure cost more than 20 million U. S. dollars.

WEIGHTY IMPORT, some 250,000 metric tons of river rock were trucked and barged from northern Bangladesh to this stoneless delta area. Relay teams unloaded the boulders (***right***) to fill gullies and hold down bottom-protecting mats (***far right***), here exposed at low tide on closure day.

Working from assigned and flagged stockpiles, laborers swung 600,000 bags into the gaps, creating a bund, or embankment, three meters wide on top and two meters high in a record seven hours.

The tide rose against the impenetrable bund (***right***) as dusk fell on February 28. The closure was a success. Men along the embankment covered the seaward side with protective polypropylene fabric. Curious villagers, foreground, gathered to watch the final effort.

The laborers wore their best clothes, treating this momentous day as a festival. As each team finished, its members started celebrating, garlanding and lifting their jubilant foreman (***above***).

During the following week dump trucks and earthmovers added clay to raise the height above the next spring tide.

ON A NEW TRACK villagers from the west-bank town of Sonagazi can now cross the river to the Dhaka-Chittagong highway on the dam's revetment, a 25-kilometer shortcut. To the left of the man carrying paddy for threshing, vehicles can travel a one-lane asphalt road along the dam's apex.

The dam (***lower left***) arrows across the Feni channel and doglegs over a hand-dug water bypass, foreground, where a sluice regulates the release of river water. Dikes connect the dam to existing coastal embankments. Fishermen portage boats around the barrier.

The ten-meter-high dam proved so strong that it easily withstood the storm surges of a tropical cyclone that whipped out of the Bay of Bengal three months later, striking the area directly and taking thousands of lives.

Rice planted in July and watered by the summer monsoon ripened in December (***far right***). Now for the first time, using irrigation, a second crop can be planted and harvested during the year.

The project's success points to the feasibility of similar operations elsewhere. The Dutch government has completed studies for a 25-kilometer dam connecting Sandwip Island to the Bangladesh mainland, employing some of our methods. And West Bengal, India, is interested in applying our engineering techniques in diking some areas of the Sundarbans in the Ganges Delta. □

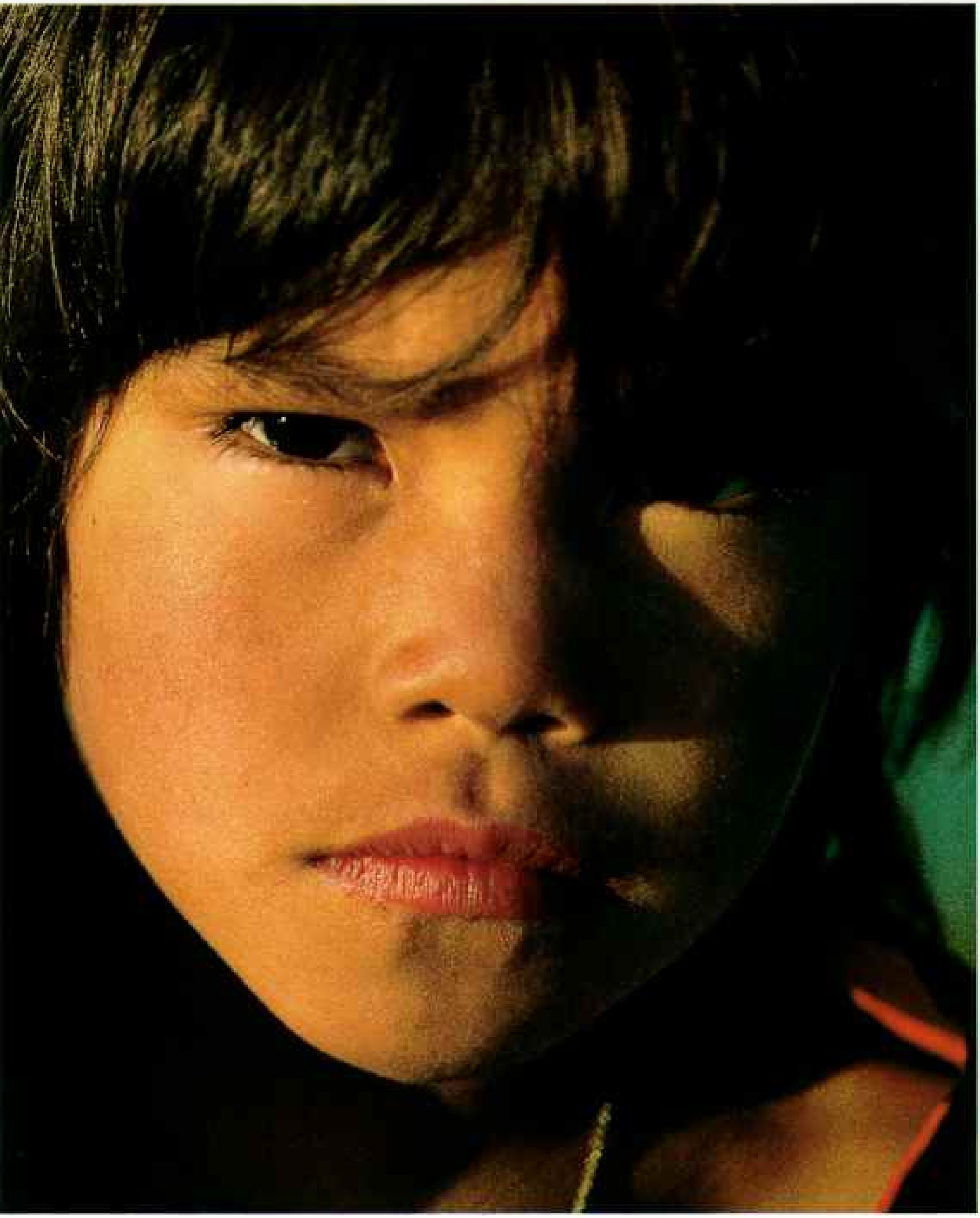
In 1985 **Hans van Duivendijk** received the highest award of the Association of Consulting Engineers of the Netherlands, the ONRI Riband, for his Feni River closure concept.

In his eyes burns a fire perhaps 10,000 years old: an ancient bond forged between his people and a mist-shrouded archipelago off the coast of British Columbia. Donny Edenshaw is a Haida, descended from master boatmen, hunters, and artists who for hundreds of generations have dwelt in moss-covered forests at the sea's edge in the Queen Charlotte Islands.

From giant western red cedars his ancestors fashioned totem poles, longhouses, canoes, and paddles such as the one beside his face, as part of a unique cultural heritage. That heritage today is put to the test as the Haida struggle to keep loggers from felling the last of the oldest cedars.

Canada's Queen Charlotte Islands

HOMELAND



By MOIRA JOHNSTON Photographs by DEWITT JONES

OF THE HAIDA

FEW PEOPLE HAVE SEEN these misty, storm-lashed isles. No palm trees beckon to this remote place. Yet the Queen Charlotte Islands, cradled off North America's northwest coast, are among the globe's rare jewels. A dagger-shaped assemblage of 150 islands, the Charlottes are a wilderness of the first rank, abounding in treasures. The brooding rain forests that coat the islands' mountainous hide hold some of the finest surviving stands of ancient cedar, spruce, and hemlock.

Isolated for millennia (and inhabited now by only 2,500 humans), these islands are also an evolutionary crucible that forged dozens of unique endemic varieties of both plants and animals, as well as puzzling disjuncts found only in the Queen Charlottes and a few scattered parts of the globe. Known as the Canadian Galápagos, the Charlottes

Lord of the sky, the bald eagle thrives in the Charlottes' lush coastal forests. There are more eagle nests per square kilometer here than in any other part of Canada, as well as the highest density of breeding peregrine falcons and a multitude of nesting seabirds. The eagle lends its name to one of the two clans into which Haida society is organized, the other clan being the Raven.

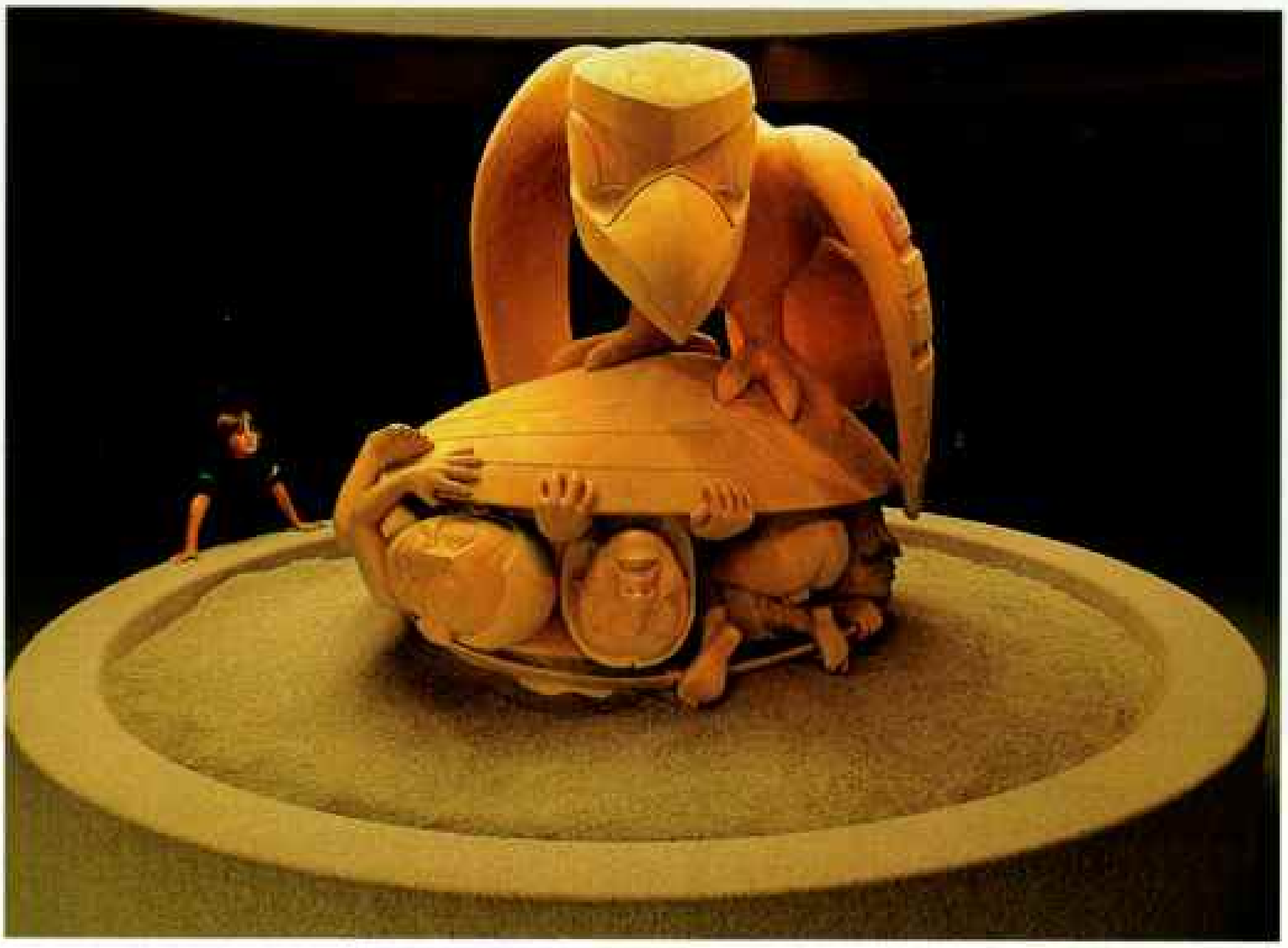
have evolved the stickleback fish to a diversity rivaling that of the more famous archipelago's finch. Here scientists have found giantism—in Canada's largest black bears and in deer mice. They have also found the smallest subspecies of saw-whet owl. Among other fauna and flora unlike any on earth are marten, dusky shrew, Steller's jay, hairy woodpecker, several beetles, saxifrage, alpine lily, and mosses that roll over

the islands like a luxuriant green carpet.

And as the mists of prehistory begin to lift, the tantalizing possibility grows that the Charlottes may have been a port of entry—an ancient Ellis Island—for tribes migrating from Asia, an alternate route to the Bering land bridge and mid-continental corridor. With mounting evidence of refugia, those ice-free nunataks and coastal bluffs that could have sustained human life during the last glaciation, scholars such as Dr. George MacDonald, director of Canada's Museum of Civilization, believe that the Charlottes, during the next decade, "may well prove central to the quest for major discoveries on man's entry into North America."

ABOVE ALL, these islands are Haida Gwaii, "homeland" of the Haida, the sea-roving lords of the coast, who, on this stormy outpost, built a culture that became "the apogee of the Northwest Coast; unequivocally the most advanced of any hunter-gatherers," Dr. MacDonald claims. Here, on strands of pebble beach pressed between the forest and the sea, a few thousand Haida created an art so vital, yet so refined, that it retains a universal appeal. Because of contact with the mainland made possible by the Haida's superlative oceangoing canoes, the art shares much, in look and style, with that of other Northwest Coast peoples. But the Haida work excelled, many art historians feel, and withstood even the white man—bursting, in fact, into a veritable golden age before being engulfed by the diseases, alcohol, and missionary ideologies of the "iron men."

It survives still, with the great Haida artist Bill Reid fashioning a massive bronze sculpture of a Haida canoe commissioned for the new Canadian Embassy in Washington, D. C. But even as their art is honored as a national symbol, the remnants of the lords of the coast, now a scant 1,500 concentrated in Masset and Skidegate villages, struggle



The first men were discovered by the Raven in a clamshell at the northeast tip of Graham Island (**right**), *says a Haida legend. A compelling yellow cedar carving of the myth* (**above**), *by Haida artist Bill Reid, greets visitors to the Museum of Anthropology at the University of British Columbia in Vancouver.*

Queen Charlotte Islands

WARMED by a Pacific current, the archipelago's two large islands and 150 smaller ones enjoy a mild, moist climate much like Vancouver's, 650 kilometers to the south. Named by Capt. George Dixon in 1778 after his ship—and the wife of Britain's George III—the Queen Charlottes are known as Haida Gwaii—"homeland."

to retain their hold on their homeland.

"The fate of the land parallels the fate of the culture," states Miles Richardson, young leader of the Council of the Haida Nation. And the land is at risk; the last of the old-growth cedars—the Haida stuff of life—have been falling to the logger's chain saw.

These giant cedars, symbols of the natural world that nurtured Haida culture, are the focus of the fight. Loggers armed with permits from British Columbia's Ministry of Forests have moved on the last of the virgin stands on Lyell Island, in the so-called South Moresby Wilderness south of Skidegate.

The face-off began in the autumn of 1985, when a small armada of fishing boats and helicopters brought blanket-cloaked Haida elders like 67-year-old Ethel Jones and parka-clad younger Indians to blockade a logging road on Lyell Island's Sedgwick Bay. Seventy-two people were taken into custody during the months-long confrontation. Strengthened by "the faces of our young boys who thought they were fighting all by themselves," Ethel Jones was arrested by her own nephew, a Mountie, who wept as he led her away.

I saw the modern conflict of resource exploitation versus cultural preservation in the Haida themselves, in a ceremony in 1986. A stately procession of half a dozen hereditary chiefs gathered on the bluff above Skidegate's beach, with hundreds of others,

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Author **Moira Johnston** has previously reported on California's Napa and Silicon Valleys for NATIONAL GEOGRAPHIC. Photographer **Dewitt Jones** is a frequent contributor to the magazine.

*Haida art is the "end product of our natural environment," says Bill Reid (**above**), one of Canada's finest living artists. Once nearly forgotten, Haida carving now flourishes profitably. "Everyone's doing it," says Nelson Cross of Skidegate, whose sea-monster platter, carved in slate-like argillite, combines grizzly bear and killer whale designs.*

awaiting a historic event. Ermine-draped headdresses crowned with carved frontlets and foot-long sea lion whiskers topped red-and-blue button blankets—so called for the pearl buttons that traced the traditional Haida designs.

The deeper identity of these men lay in their chieftainships of Tanu, Skedans, and Cumshewa, of Tian, Yan, and Yakan Point—abandoned ghost villages embedded in the moss along the Charlottes' coastline. Yet peeking from beneath their colorful regalia were modern collars, ties, and T-shirts that betrayed daily lives as fishermen, loggers, policemen, and office workers in the larger culture of Canada.

Then, as if choreographed, an eagle circled against the intense blue April sky, signaling the arrival of the 50-foot-long canoe as it rounded the point east of Skidegate. The flash of the bird's snowy head and wingtips mirrored the rhythmic flash of 12 glinting paddles. It was tempting to believe that the Eagle—Chief of the Sky Beings—was heralding a return to the old order of things, when hundreds of great Haida canoes plied these waters.

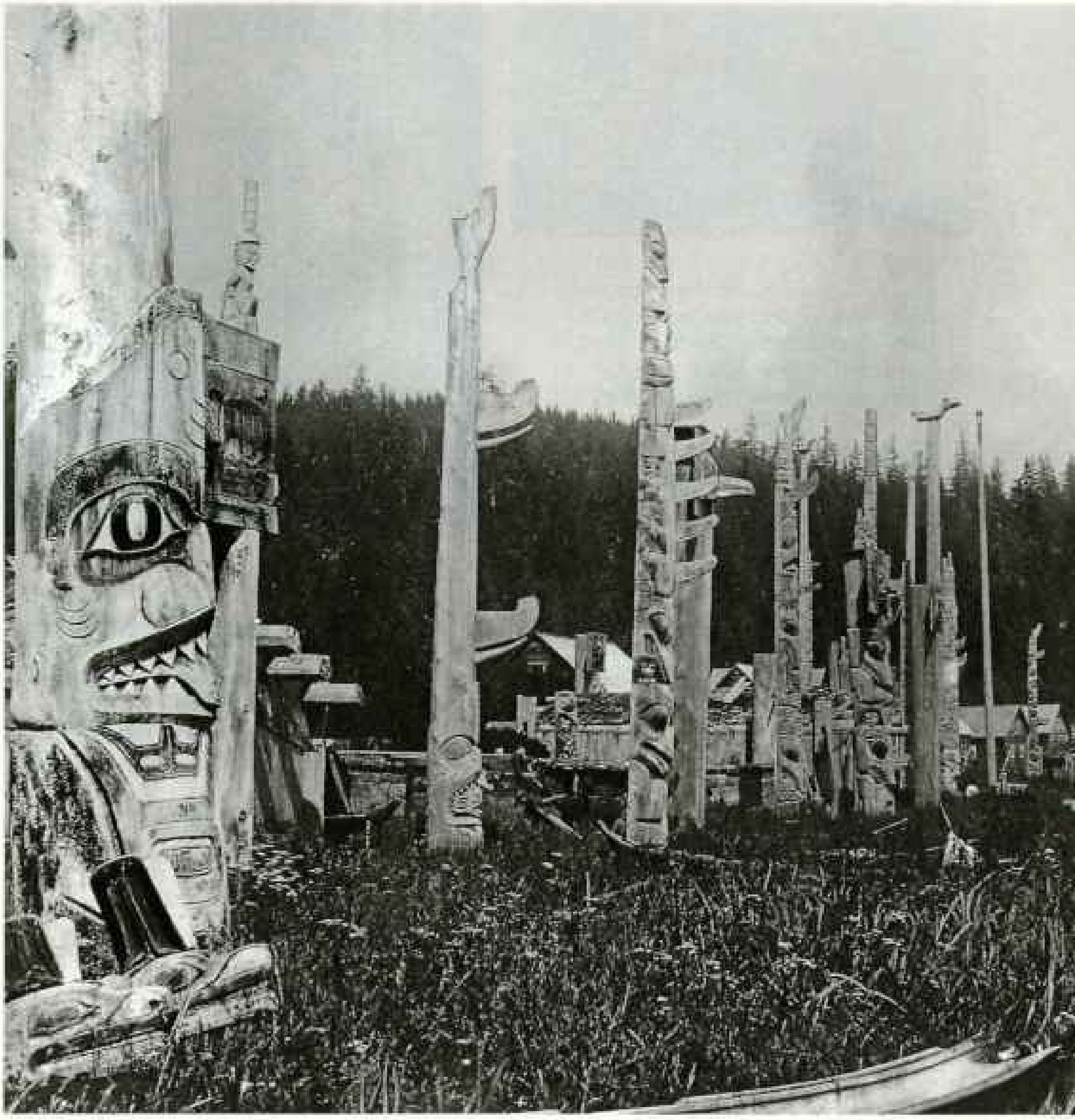
As the canoe drew nearer, the red-and-black design on its prow took on definition: the dramatic lines that run through Haida art traced the big stylized teeth of the Killer Whale, Chief of the Sea Creatures. Standing nearby in his button blanket, Bill Reid, who designed the craft, whispered, "The Haida canoe is as beautifully designed and decorated an open boat as the world has ever seen." The chiefs proclaimed the canoe *Wave Eater*. *(Continued on page 114)*

*Paddling out of history into the Charlottes' clear, cold waters, a group of Haida from the village of Skidegate take a trial run in a new canoe (**right**) —the first in generations to be built in the traditional style developed by Haida traders and warriors. The 50-foot craft, designed by Bill Reid, was shown at Vancouver's Expo 86 before being returned to the village this spring.*

*Standing tall on Skidegate's beach at the turn of the century, rows of totem poles (**below**) display the family crests of those who occupy the cedar-plank longhouses next to them. Most poles, such as the one with the shark design, at far left, commemorate an important event in the life of the head of the family. A few are mortuary poles, holding the remains of their owners.*

The Haida left villages such as Skidegate to gather food: salmon, halibut, black cod, trout, caribou, clams, birds' eggs, berries. So plentiful were the land and sea that the Haida were never forced to farm. Instead they became the world's most densely populated society of hunter-gatherers—a people with time enough to create lavish decorations on their canoes, houses, and totem poles.

*Today about 370 Haida inhabit Skidegate (**below right**). Most make a living by logging or fishing; at least 18 are full-time carvers.*



SMITHSONIAN INSTITUTION

ROBERT SEMENIUK (TOP); DEWITT JONES

Did loggers step over the line on Lyell Island? Yes, say environmentalists and Haida leaders, who argue that clear-cutting—seen here—is destroying irreplaceable wilderness and infringing on ancestral lands. For decades timber companies operating throughout the archipelago provided much needed jobs. But when

a logging company moved into an area of Lyell Island proposed as a national wilderness park, a protest spread across the nation. In March 1987 the British Columbia government stopped issuing new logging permits, and negotiations resumed with federal officials over the South Moresby park proposal.

In mourning paint, a Haida group in November 1985 protests logging on Lyell Island. Says a spokesman: "How can we weigh the jobs of loggers against a people's homeland?"

I had waited for hours to see the canoe; the Haida had been waiting half a century. Few living Haida had ever seen this sight. The boat had been built for display at Expo 86, the international fair that was about to open in Vancouver. But *Wave Eater* also seemed a spontaneous assertion of Haida worth and achievement at a time of crisis; the same impulse had spurred a burst of soaring totem poles and elaborately staged potlatches (the lavish gift-giving feasts that confirmed status and redistributed wealth) when the Haida had faced an earlier crisis—the coming of the white man.

ONE OF A NEW BREED of white man told me about it: American-born Thom "Huck" Henley, who runs a wilderness camp called Rediscovery that puts Haida children in touch with their roots through forest games, food gathering, songs, dances, and potlatches. He led me up a steep finger of rock overlooking a spectacular white beach at the northwest corner of the Charlottes. This crag, known as Lookout Point, is thought to be the place from which, in 1774, boys from Kiusta village spotted the first white sail.

Juan Pérez had captained that ship, the *Santiago*, which was leapfrogging up the coast from the Spanish base at Monterey in an effort to preempt the Russian presence in Alaska. The French also cruised by. "But trading didn't begin in earnest until 200 years ago, in 1787, when a British captain, George Dixon, sailed in over there," said Huck, pointing to Cloak Bay.

Dixon named the islands after his ship, the *Queen Charlotte*. He had come to trade for lustrous furs like those that cloaked the curious Haida who encircled the earliest ships with their canoes—a people described as "of fine physique being six feet in stature, whilst . . . much fairer in complexion than those of the mainland." A Dixon subordinate, William Beresford, wrote: "The number of sea otter skins purchased by us at Queen Charlotte's Islands was no less than 1,821, many of them very fine."

Thus was launched half a century of aggressive barter in sea otter pelts for China. Enterprising Boston traders swiftly joined the British in an era that transformed the Haida world, triggering an extravagant outpouring of their art and of stone carving for trade, but also undermining ancient ways and driving the sea otter to eventual extinction here. The Haida, who quickly developed a hunger for trade goods—especially the iron tools that allowed them to carve better and bigger totem poles, canoes, and houses—collaborated in that extinction. They were the hunters.

And magnificent seamen. Stacey "Jags" Brown, *Wave Eater's* chief carver (and son-in-law of designer Bill Reid), told me: "The diaries say that when a sailing ship [*Gustavus III*, captained by Thomas Barnet] reached Cloak Bay in the late 18th century, 600 Haida canoes came out and circled the boat, and that at Skidegate and the other villages you couldn't even land, there were so many canoes pulled up on the beach."

It must have been a commanding sight. Against a forest backdrop, a row of 20 or 30 handsome cedar longhouses had faced the harbor, flanked or fronted by stands of totem poles embellished with the Raven, Eagle, Bear, Wolf, Beaver, Dogfish, and Killer Whale designs—symbols and sub-symbols of status and lineage similar to the heraldic crests of Europe.

In their massive dugout cedar canoes the Haida had long raided and traded with mainland and Vancouver Island tribes—Tlingit, Tsimshian, Kwakiutl—and, later, with European traders in Victoria. During the brief summers they turned the treacherous 60 miles across the Hecate Strait and the 200 miles south to Vancouver Island into Haida freeways. During the dark stormy winters they gathered in cedar houses and elaborated their rich culture with art, stories, and ceremony. With the bounty of the forests and teeming tidal zone, the Haida had the building blocks of civilization—abundance and leisure—without ever having to take up a hoe.

"Never having made the shift to food production, they never had any reason to change their cosmology, their vision of life,"

explained Dr. George MacDonald. "Art and culture evolved in an unbroken line over at least 9,000 years."

The art's rigid and complex code of design conventions—and its pantheon of human, animal, and supernatural beings—seems clearly born of more ancient roots than the bits of post-glacial artifacts that have been found. Paleobotanist Dr. Rolf Mathewes of Simon Fraser University has collected 15,000-year-old plant remains from the low silt cliffs of Cape Ball, north of Skidegate, that are closing the gaps that still exist in the environmental record of the Charlottes. His ancient seeds and pollens offer proof that firs were alive on the islands before, and well into, the last glaciation—as much as 24,000 years ago. Human life *could* have been there, he says.

In quest of proof of "an unbroken refugium throughout the last 30,000 to 40,000 years," during which the ancestors of the Haida arrived, Mathewes fights the fact of the Charlottes: There is no written record, and most early ruins lie decayed or buried in bogs and rain forests, or submerged by rising sea levels in Hecate Strait. Haida history beyond the span of human memory is still shrouded in Mythtime.

BILL REID is quite comfortable with Mythtime. The artist (page 109) had introduced me several years ago to his most famous work, a massive yellow cedar sculpture of the Haida creation myth that sits as the centerpiece of the University of British Columbia's Museum of Anthropology. "Though the world view might hold that man migrated over a Bering land bridge," he said drolly, "the Haida know that the Raven coaxed the first men from a clamshell on the beach at Naikoon." In Reid's sculpture the Haida culture hero, the Raven, a curious and gluttonous prankster, pries open a giant clamshell to reveal the tangled bodies of men writhing to get out.

My own probe of Mythtime had begun with a search for that site of creation. I helicoptered north over the Charlottes, sharing a view of Haida Gwaii with the eagles. What a homeland! Forested islets carved from the sea like pieces of a jigsaw puzzle, deep inlets stained iodine black by runoff from the islands' mosses, steep landforms wrapped in gauzy mist the color of clamshells. And, at the far northeastern tip of the Charlottes, a finger of sand reaching out into the converging currents of Dixon Entrance and Hecate Strait. My crisp new map identified the

beach below as Rose Spit, but to the Haida it is—as it has always been—Naikoon, the place where the Raven brought mankind into the world.

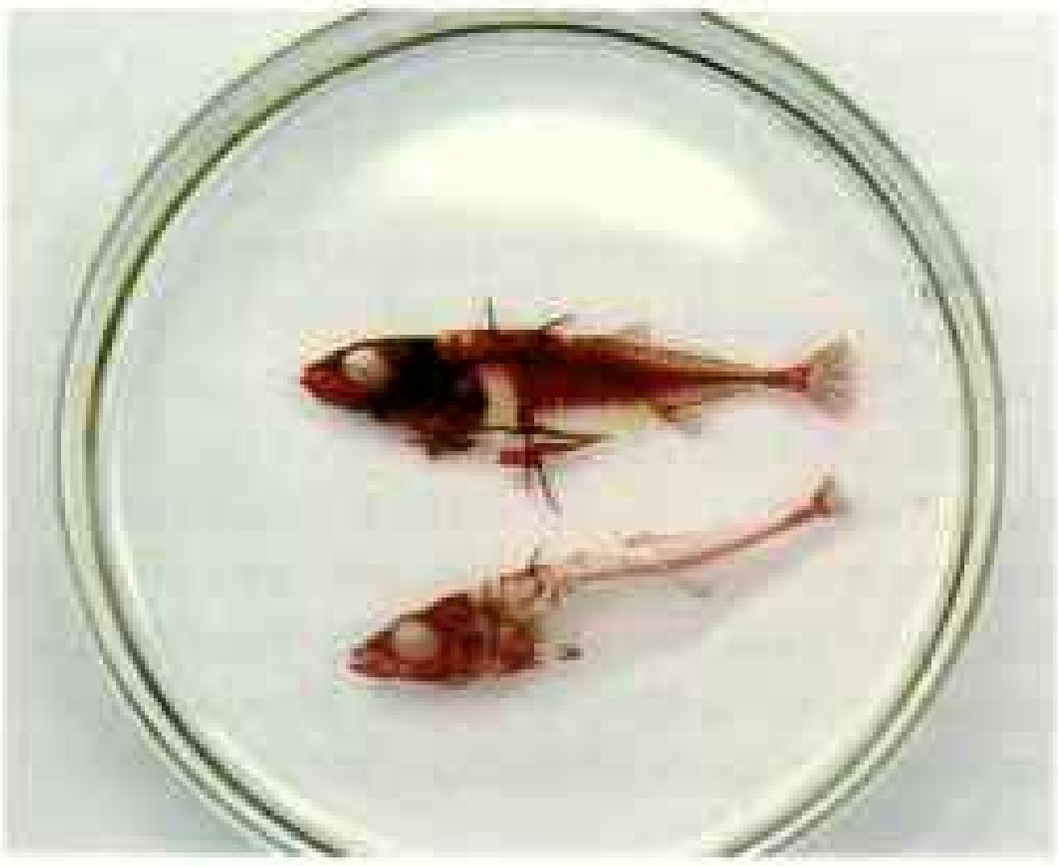
Bill Reid was my guide not only to the Haida's Mythtime but also to Windy Bay, crown jewel of the hotly contested South Moresby Wilderness.

Physically the South Moresby Wilderness is a 75-mile-long triangle—roughly 15 percent of the Charlottes' landmass. It narrows from a 22-mile width in the north to the rocky point of Cape St. James in the south, where the fierce winds of winter storms can reach a hundred miles an hour. Site of one of the continent's last and most majestic remnants of first-growth coastal rain forest, it has, so far, resisted the hand, saw, and seine of man that have transformed the face of northerly Graham Island.

IF THE SEA fed the Haida body, the forests of South Moresby feed the Haida soul. Venerable spruce, hemlock, 1,200-year-old cedar, all are precious to the Haida. But the cedar commands a special reverence. In the words of archaeologist Philip Hobler: "Cedar provided the distinctive architecture, the transportation system, the clothing, the material to be carved into artwork and ritual objects,

*Canada's Galdpagos: Thus do scientists describe the Charlottes for their isolation and genetic diversity. Dr. Tom Reimchen of the University of Alberta (**above**) has found different varieties of sticklebacks (**below**) in nearly every lake he has studied. The bony plates (dyed red for identification) of the fish at top, which lives in deeper water, help it avoid being chewed by trout, while the lack of plates in the shallow-water variety below may make it flexible enough to elude the grasp of dragonfly larvae.*

*The rocky southern coast (**right**) of the archipelago provides breeding areas for half of Canada's Steller sea lions.*



a place to store surpluses—the basis of wealth. Subtract cedar and you don't have Northwest Coast culture."

Bill and I threw our duffles aboard the 70-foot sailboat *Darwin Sound II* at Moresby Camp, south of Sandspit, and sailed off for a firsthand look. Capt. Al Whitney, with his wife, Irene, reminded us that "from here south there will be no roads, no residents. The inhabitants are bears and eagles."

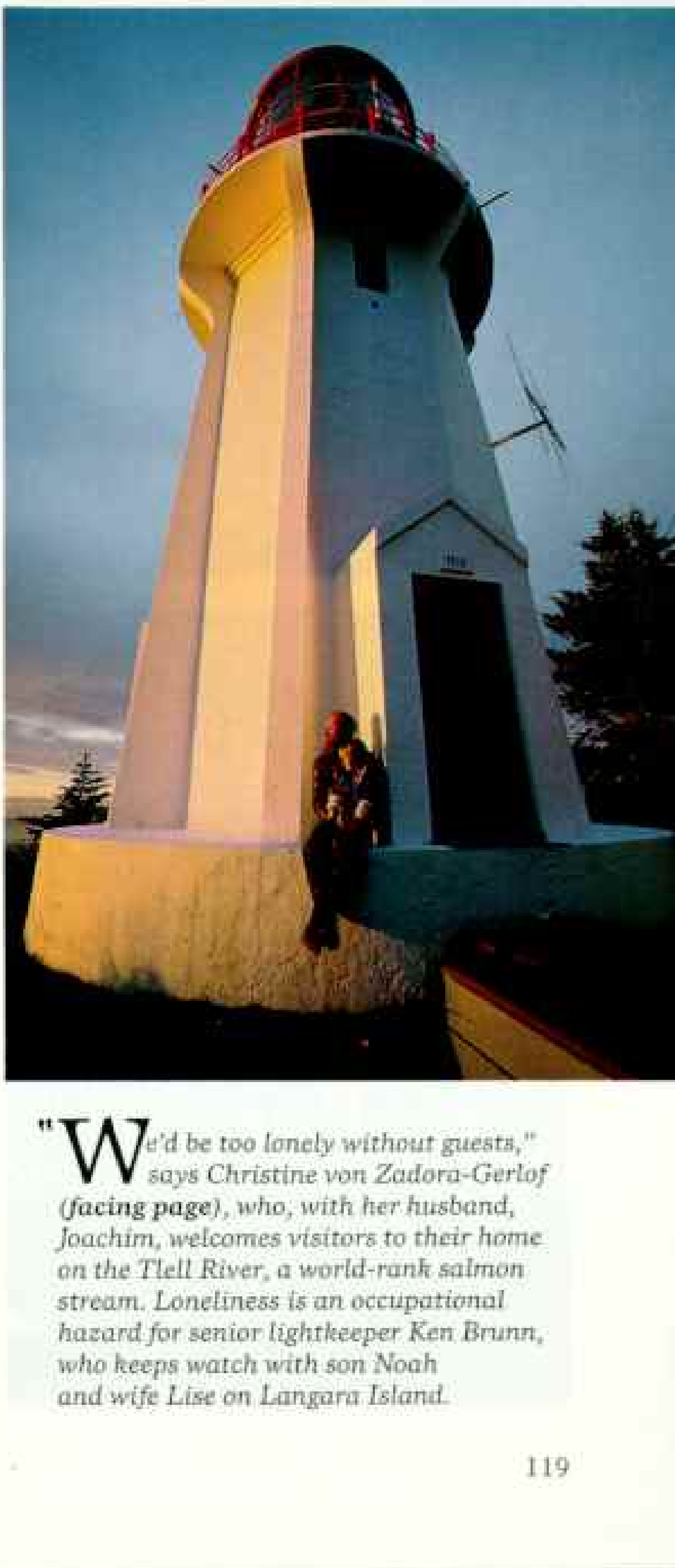
Moving deeper into the wilderness, we paused at Burnaby Narrows to marvel at a low-tide tapestry of brilliantly colored beds of anemones, clams, abalones, sea urchins, crabs, and starfish in shiny tangles of kelp. "Just boil it, and you've got bouillabaisse," Reid joked. The joking stopped at the first sight of the logged-off slopes on Talunkwan Island. And his voice broke with emotion as we reached Windy Bay and headed on inflatable skiffs toward the stand of trees that had become the symbol of the fight to save South Moresby.

The forbidding forest wall we had seen from the beach opened into a world of half light and fantastic shapes. A velvet carpet of moss rolled over everything, muffling sound and taming the chaos of upthrust roots and deadfalls. Rising from the tangle were trees as majestic as any redwood I had ever seen. Stories above us a filigreed canopy of licorice fern, mistletoe, lichen, and moss kept the forest floor in permanent twilight. On the ground, beneath the towering cedars that were seedlings long before Columbus was born, new trees sprouted in neat rows on rotting nurse logs.

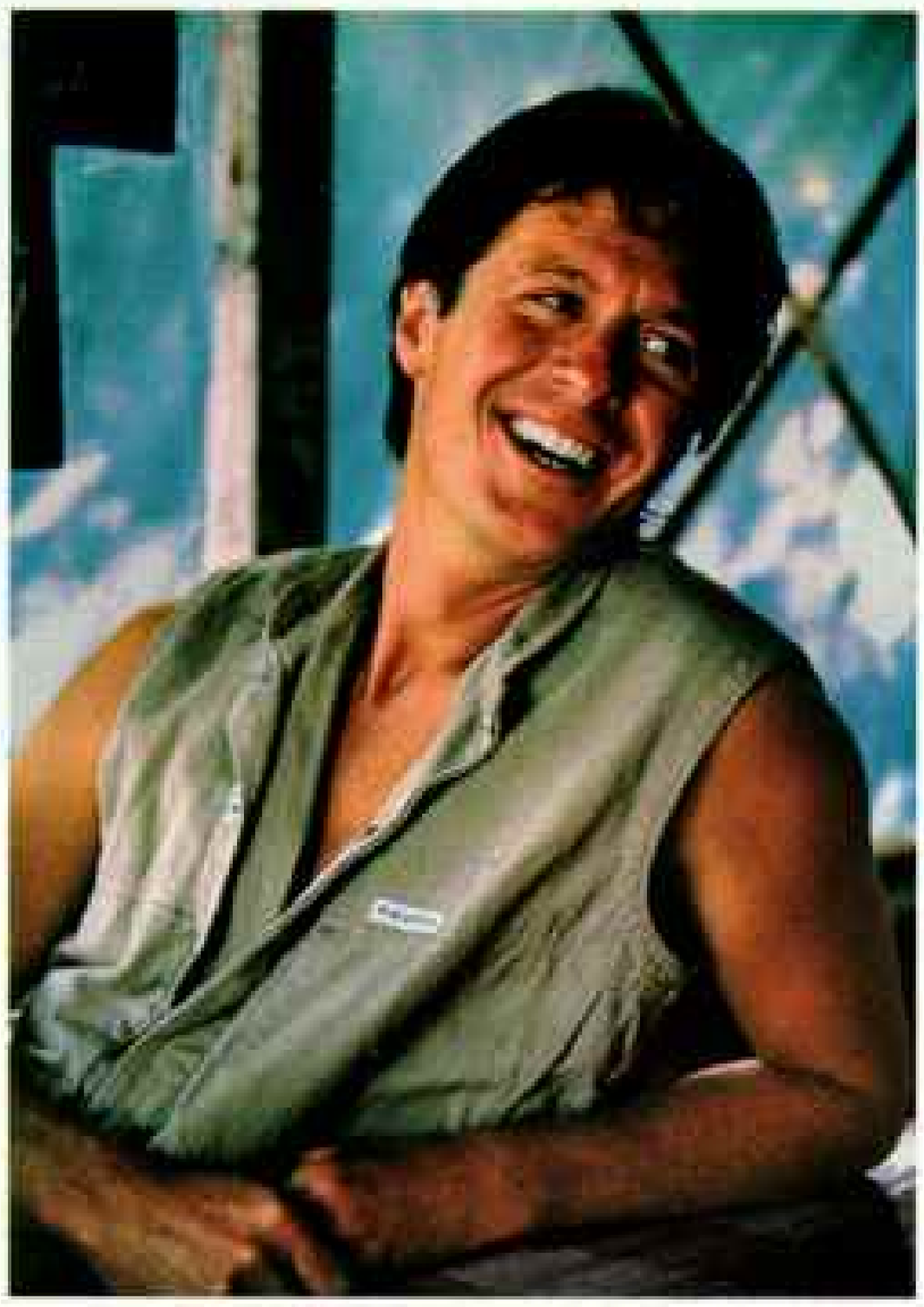
"I feel the life force in here," Reid said. "It's an extremely sensual—almost sexual—experience. It makes me want to become a part of the forest."

IN THE GHOST VILLAGE of Tanu, an hour's sail north of Windy Bay, Reid tapped the source of his own talent. Tanu had been a center of art for the southern Haida, and his mother's ancestral home. It was where Reid's great-aunts and great-uncles had died at the water's edge during the smallpox epidemic that followed the arrival of the white man.

Indeed, contact with the Europeans swamped the Haida like a tidal wave. New trade patterns and values engulfed their culture; totem poles came tumbling down, condemned by missionaries as graven images; and during two terrible years in the 1860s the Haida were devastated by the pox, which killed some 70 percent of them. A Hudson's Bay Company census about 1841 listed 6,600 Haida in 13 Queen Charlotte villages; by 1900 there were only 900 (the offshoot Kaigani Haida of Alaska's Prince of Wales Island dwindled from 1,700 to 800 in the same period). Survivors abandoned the villages and fled to Masset and Skidegate



"We'd be too lonely without guests," says Christine von Zadora-Gerlof (**facing page**), who, with her husband, Joachim, welcomes visitors to their home on the Tlell River, a world-rank salmon stream. Loneliness is an occupational hazard for senior lightkeeper Ken Brunn, who keeps watch with son Noah and wife Lise on Langara Island.



"I do, I touch, I understand." This is the hands-on philosophy of Thom "Huck" Henley **(left)**, who founded a summer camp at Lepas Bay **(above)** in 1978 for Haida youths with problems at home or with the law. Expanded since to include children of all backgrounds, the two-week Rediscovery program kindles respect for nature and Haida culture through wilderness adventure. Haida elders often visit to teach about life in ancestral villages such as Kiusta, where Huck takes campers for workshops **(upper left)**. Because of Rediscovery's success there are now seven camps like it in British Columbia and the U. S.

after the dread disease had run its course.

The artist led us across Tanu's small shell-and-pebble beach to a grassy bluff where the houses had stood. A thick blanket of moss now shrouded shapes that had been house beams, planks, and totem poles. One lurching pole had been cleaved by a spruce that was growing through its heart, splitting the heads of the animals that had been a family's proud crests. All Haida are either Raven or Eagle, and at the Raven end of the village Reid seated himself at the bottom of a large mossy depression that had been his family's home. Just feet from where he now sat, the longhouse fire had once burned, lighting the spacious excavated floor and shelved sleeping platforms.

"Those early Haida had no kings or even tribes; each village had several large matrilineal families," Reid explained. "A man inherited rank, lineage, and wealth from his mother's brother—the family chief, who saw himself as great as any tsar of Russia. Rivalries among the chiefs and their need to reassure themselves of how great they were may have spurred production of the art."

In the Charlottes' forests I saw traces of the Haida's time of sorrow—giant canoe logs, cut and left where they had fallen, the adz marks of carvers still visible. Examples of the great skill of Haida canoe builders survived only in museums and in the sepia images of 19th-century photographs. Until today. Until *Wave Eater*.

*Lady of nobility, Florence Davidson is the daughter of Chief Charles Edenshaw, famous Haida carver. Known to all as Noni, or "grandmother," she owns enough china to serve 90 at a potlatch. Foods at these festive occasions include, clockwise from top (**below**), jars of smoked salmon, dried herring roe on kelp, dried clams, smoked salmon filets, dried seaweed, dried halibut, and eulachon grease—fish oil.*

The canoe project put adzes into the hands of rugged loggers as well as artists—a step toward giving today's Haida the tools of competency and the values of their ancestors. A decade earlier Reid had carved for the Skidegate Band Council the 60-foot cedar totem pole that fronts its council house. The art renaissance he had launched in the 1950s, after a fitful start as young artists fought those chronic symptoms of aimlessness and despair—drugs and alcohol—had taken hold and flourished.

But the city-raised Reid had had to turn to museums and libraries to learn the "expressive language" of his own people's art. Using his great-great-uncle Charles Edenshaw's work as "my Rosetta stone," he had (simultaneously with Seattle professor Bill Holm) broken the code of the intricate art, identifying and naming the basic themes repeated again and again in the designs—the form lines, ovoids, U-curves, joint marks that give Haida art its elegance and look of contained energy. With Reid's pieces setting the

pace, there developed a profitable international market for Haida gold and silver jewelry, carvings from the local argillite shale, prints, baskets, and totem poles. Dozens of artisans were at work in the Charlottes and in Vancouver and Victoria.

Reid worried, however, that "this so-called renaissance of art has barely touched native society. Most don't know the stories, the values, their sub-crests. In museums they respond to *trade beads!* I want them to know that only three generations ago people lived richer, fuller, more satisfying lives than you can imagine. . . . I want them to know that they came from *marvelous* men."

The canoe project, sponsored and funded by the Bank of British Columbia, involved many of Skidegate's young people, but none knew how to steam a canoe. So Jags Brown first carved a tiny model and steamed it in his wife's roasting pot on the kitchen stove. The steaming of the 50-footer on the bluff at the east end of Skidegate was a scene from Dante's inferno. "We dumped six inches

of water into a groove cut along the log's length, rolled wheelbarrows of red-hot rocks up a ramp, and shoveled them in. Steam was shooting all over the place." As elders watched, eyes moist with pride, the cedar turned soft as rubber and spread 20 inches by itself. "Then a crew of young guys held on to the upper edge and stretched the canoe to the classic shape."

Perhaps Jags's greater contribution was the stand he took to preserve the endangered South Moresby Wilderness, a conundrum for a man who earns a good living as a logger. "My father was the first logger in the village," he said, "and you do what your father does. But I supported the blockade, and as a logger I say, 'No logging.'"

OF ALL THE HAIDA VILLAGES, Ninstints, on Anthony Island at the southern end of the Queen Charlottes, had been most isolated, most exposed to Pacific storms, and most fiercely resistant to change. Here, on a classically sheltered bay, the largest number of totem poles survived. Many of the best were removed to mainland museums during a 1957 recovery project, but enough remained to win, in 1981, global recognition as a UNESCO World Heritage Cultural Site, a designation that focuses national pride and international prestige, thus tending to ensure preservation.

It is the designation that many Haida—and Canada's Minister of the Environment Tom McMillan—would like to see awarded to the entire South Moresby Wilderness. But first it may well become a provincial or federal park, a goal that 13 years of struggle has not yet achieved.

The preservation storm that began brewing in Haida Gwaii in 1974, when Indians and environmentalists formed a citizens' action group to protest exploitation of South Moresby, polarized the islands. Though

Lofty refuges, Mosquito Mountain and other island peaks may have risen above the ice fields that covered much of North America 20,000 years ago. Thus they could have preserved species of plants that now exist only here and in far-flung spots such as the Himalayas.

the contended timber represents only two-tenths of one percent of British Columbia's forestlands, emotion ran high. Fear of imminent job loss spread among the Charlottes' logging-dependent families, a fear compounded by a prolonged recession and the long-term attrition of the industry that, in British Columbia, had been king.

"It's the uncertainty that kills you," logging contractor Frank Beban told me, his back quite literally against the wall in the coffee shop of the Beban-owned Sandspit Inn. Beban's concern was real—and immediate. He held the timber-cutting contract with Western Forest Products, the company that was granted Tree Farm License No. 24 permitting logging of contested Lyell Island. It was Beban's crews—Indians among them—that had been stopped by the Haida blockade at Sedgwick Bay. An affable bear of a man, Beban claims that without the jobs that logging provides, even more of the younger Haida would be forced to migrate to the mainland. "Half the Haida in Skidegate are in logging," Beban says.

Miles Richardson, the young college-educated activist who in 1985 assumed the presidency of the Council of the Haida Nation, has little sympathy for Beban's view. "We're not talking about 70 logging jobs," he stressed. "We're talking about forever. The issue is not logging versus 'eco-nuts.' It's our ability to sustain our culture. And that lies in our relationship—as a people with a 10,000-year history—to the land and the sea and their resources."

"Jobs lost would be more than compensated by establishment of a national park and increased tourism," said Tom McMillan, expressing the commitment of the federal government in Ottawa to preserving South Moresby "for Canadians yet unborn and for the international community."

But where does Lyell Island fit into the plan? "If it's a park, it's a wilderness park, and you can't have it facing clear-cut logging," asserted Minister McMillan. Yet this spring logging crews ripped through Lyell Island with unprecedented speed, leaving ravaged slopes visible from the core area of the proposed park, bringing the region closer daily to disqualification as a park by Parks Canada's aesthetics guidelines. "I fear the Charlottes will soon be Galápagos Lost," lamented Jim Fulton, member of Parliament for the Charlottes.

As international pressure grew, the first glimpse of serious provincial sympathy for the conservation option was revealed in the Speech from the Throne this March by new British Columbia Premier William Vander Zalm: "We will attempt to expedite the federal-provincial negotiations for establishment of a national park on South Moresby that will generate economic benefits for all British Columbia."

Later that month the provincial government announced a six-week moratorium on new cutting permits in South Moresby, while logging continued at breakneck pace on the contested slopes.

Fearing that words were not backed by the will to end logging on Lyell, Bill Reid—in protest against "the contradiction between the government's attitude toward the Haida and the showcasing of their symbols"—withdrew his canoe sculpture for the Canadian Embassy in Washington.

"We've put our money on the table to compensate the loggers," stated McMillan, determined to preserve cutting boundaries that would include Lyell Island and to push for a national park that would bring new prosperity to the entire province.

AND TO THE HAIDA. Wealth, by whatever name, has always been part of the Haida equation. A measure of status. A spur to rivalries, to potlatch, to elaborate display. Wealth—or lack of it—still drives rivalries between the two Haida villages, though it is measured today by the freshness of paint on plain frame houses and the condition of cars and pickups as well as the lavishness of potlatch gifts. And also in the alarming level of drug use and alcoholism and brawls at Saturday-night dances, with the village rivalries compounded by the always difficult—often desperate—struggle to compete in the white man's economy. The frustration has erupted in several suicides and the torching of the church and longhouse at Masset.

Rivalry can also be seen in the harbors. Skidegate prospers with logging jobs and a fishing fleet that controls the "ghow" fisheries—a multimillion-dollar harvest of kelp on which herring roe has been laid, a delicacy

that Skidegate fishermen sell to Japanese buyers for $12 a pound. The Masset Haida lost their fishing fleet in the 1960s and are largely dependent on the government's human services. "Masset has been treated like the poor cousin," I was told by a woman employed by the Masset Band Council.

But she saw signs of a new bonding between the villages. "Rediscovery planted the seed, and the Lyell Island blockade strengthened it." The launching of *Wave Eater* confirmed it; most of Masset traveled south to Skidegate for the great event.

And *Wave Eater* has ignited the hope of reviving an ancient venture. The Haida had run a profitable canoe business in the past, trading them with the mainland tribes for mountain goat wool as well as oily candlefish, providing grease their islands lacked. With tourism, museum and private collectors, and television and movie production as new markets, hope rises that canoes can be a good business again.

Wave Eater has also turned angry rivalry to healthy competition. In Masset I found Morris White and his three sons hollowing out a 40-foot canoe in Morris's backyard, working in a bed of pungent red cedar chips. They were just a week from steaming and shaping the first of five canoes they plan to build, including a 50-footer.

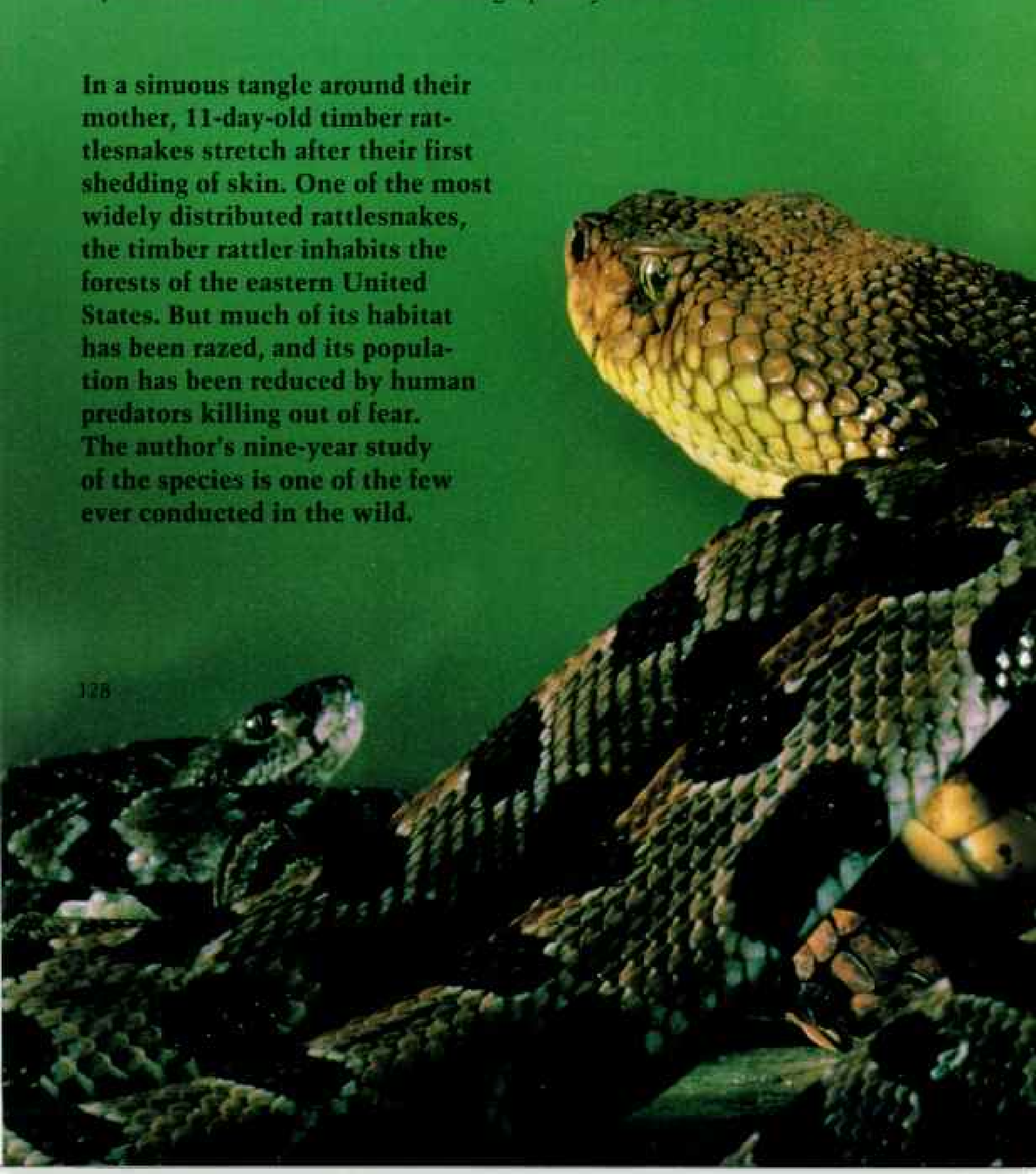
As the long storm over the Charlottes climaxed at the negotiating table this spring, *Wave Eater*—the ravages of its summer at Expo 86 repaired—lay in Reid's carving shed in Vancouver, awaiting the sturdy crewmen who were to paddle it out of the harbor and north to the islands. The same long and tortuous journey of the ancestral Haida would take *Wave Eater* home. Below Reid's totem pole a great canoe, too, would sit on Skidegate's beach. □

Taking a name that reflects his spirit, Guujaaw, or "drum," sounds off for native rights as a director of the Council of the Haida Nation. "To change the land around us," he says of logging and other plans to develop the islands, "is not unlike removing us from the land."

Hidden Life of the Timber Rattler

By WILLIAM S. BROWN Photographs by BIANCA LAVIES

In a sinuous tangle around their mother, 11-day-old timber rattlesnakes stretch after their first shedding of skin. One of the most widely distributed rattlesnakes, the timber rattler inhabits the forests of the eastern United States. But much of its habitat has been razed, and its population has been reduced by human predators killing out of fear. The author's nine-year study of the species is one of the few ever conducted in the wild.



By late September in the mountains of the Northeast, the temperature at night begins to drop. For some time before, those of us who watch for timber rattlesnakes have seen them slowly moving back toward their dens. We know that some will be caught out and die. Others will be blindly killed by people.

The first protracted cold spell "pushes them in," as we say; by mid-October the snakes are in their dens. It will be another six or seven months—spent in constant darkness in soil spaces, holes, and crevices below the freezing line—before the warm days of late April and early May entice the snakes out of hibernation. Meanwhile, those who have a fear of rattlers will be walking easier through the woods.

What they may not realize is that the snakes have not merely chosen a convenient hole in the ground. Once a den is selected for hibernation, its occupants, perhaps by a form of imprinting, stake their futures on it; they will not use any other. Many of these hibernacula, as we call the dens, may have been in continuous use for hundreds, perhaps even thousands, of years.

A RESEARCH PROJECT SUPPORTED IN PART BY YOUR SOCIETY

Each serves as permanent home for an entire population or colony. An individual snake's behavior, its seasonal migrations, its spring basking and fall mating, its success in outlasting the winter—all its activities are defined within the orbit of the den.

Finding rattlesnake dens, always a memorable activity, sometimes provides rare excitement. Early one May I climbed up among fallen rocks in a steep ravine, then sat down to write notes. Suddenly the stillness was broken by a loud whirring rattle about 40 feet upslope.

Climbing across brush-choked boulders toward the sound, I glimpsed the rattler's disappearing tail, oscillating furiously in a crevice beyond reach. Listening closely, I could hear a second snake rattling underground. Then, about 30 feet away in another direction, a third rattler sounded off. I felt surrounded! As I stood jotting down my observations, I glanced down. Right at my feet a large rattlesnake lay coiled motionless and nearly invisible in the leaves!

I had stumbled across a den area and began finding more rattlers. Some snakes were coiled out in the open, others hid under overhanging rocks. Within an hour I had seen ten rattlers and caught seven for live laboratory research.

There have been few long-term studies of snakes in the wild. Since 1978 my goal has been to census wild timber rattlesnakes and measure their natural growth and survival rates. Since members of this species (*Crotalus horridus*) live as long as 30 years in captivity, I rely in the long run on recapturing many individuals I have previously captured, weighed, sexed, and marked.

Three years ago in one of our study areas in northern New York State, my field partner, Randy Stechert, and I caught a rattler. I held up its tail to look for scars on the belly. Sure enough, there were.

"Well, all right! This is number 38!"

It was an exciting moment, for six years had passed since I had marked this female timber rattlesnake as a youngster. She was the first I'd ever seen in the wild.

I remembered her number—picked arbitrarily for easy marking (left side, clipped third scale=3; right side, clipped eighth scale=8). I had wondered if I would ever see her again.

Warily I slipped the venomous reptile into a nylon bag, attached an identifying tag, and put her in my backpack with others to be carried down the mountain.

Back in the laboratory we could "process" our rattlesnakes in detail, marking each snake for future recognition by clipping belly scales and by applying bright-colored paint to the snake's rattle. Later each snake would be carried back to its exact capture site and released.

Number 38 had weighed 82 grams and measured 52 centimeters (20 inches) long in 1978 when her two-segment rattle showed

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William S. Brown, associate professor of biology at Skidmore College, has spent nearly a decade studying the behavior and population ecology of the timber rattlesnake, work supported in part by the National Geographic Society. Dr. Brown has written widely in scientific journals on herpetological subjects.

her to be a yearling. Now seven years old and weighing 503 grams (a little over a pound), she measured 92 centimeters in length and might be ready to produce young.

I gently passed my thumb along her abdomen but felt no lumps. She lacked developing eggs. This year, at least, she would not bear young. Females typically don't reach maturity until their seventh or eighth year. Growing slowly, some may not bear young until even later in life.

The saga of number 38 reached a climax in 1986, when I captured her for the third time and found her pregnant in her tenth year, confirming the late maturity and delayed first reproduction in this species.

TIMBER rattlesnakes breed in late summer and early fall. It's rare to witness mating. Two longtime naturalists, Steve Harwig in Pennsylvania and W. H. Martin in Virginia, in 45 and 30 years respectively, have observed only six pairs mating, all in late July, August, and early September.

Mating requires that sperm be stored over the winter in the female's reproductive tract. The following June the eggs become fertilized, and approximately three months later the young are born.

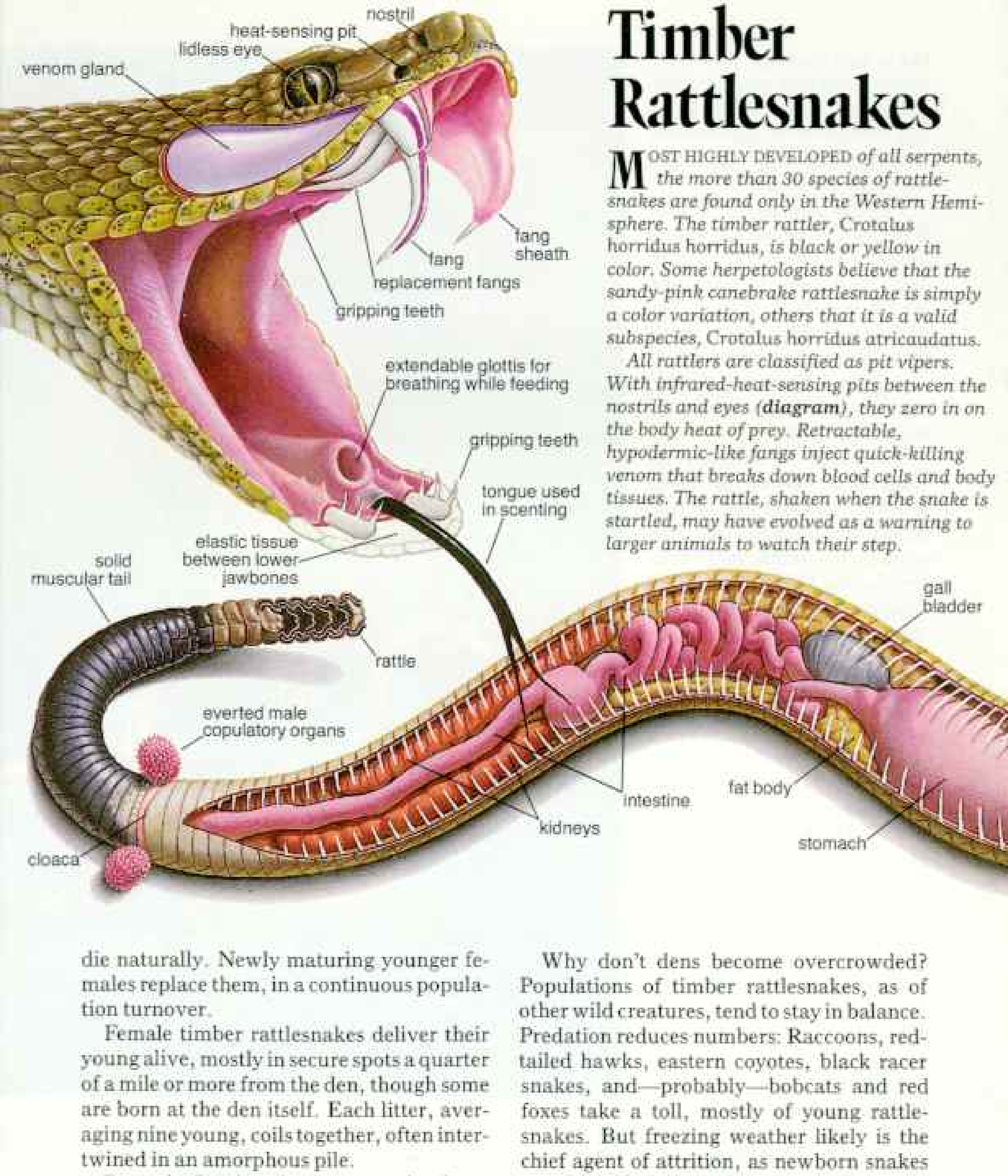
Two years are skipped between timber rattlesnake pregnancies, evidently to recharge depleted energy stores for new egg development. The reproductive frequency is triennial—at three-year intervals. So a different third of mature females are gravid and sedentary each year. At my most studied den, I have recorded for six consecutive years three or four gravid females among a population of some 12 mature females. Each year some adult females are killed by man or

Writhing fury *requires deft handling as the author bags an adult male to be marked and measured in the laboratory, then returned to its capture site in northern New York. His research helped move the state in 1983 to protect the snakes legally. Massachusetts, New Jersey, and Connecticut have similar laws. Dr. Brown has been bitten three times; the potent venom is rarely fatal to humans.*

Timber Rattlesnakes

MOST HIGHLY DEVELOPED *of all serpents, the more than 30 species of rattlesnakes are found only in the Western Hemisphere. The timber rattler,* Crotalus horridus horridus, *is black or yellow in color. Some herpetologists believe that the sandy-pink canebrake rattlesnake is simply a color variation, others that it is a valid subspecies,* Crotalus horridus atricaudatus.

*All rattlers are classified as pit vipers. With infrared-heat-sensing pits between the nostrils and eyes (**diagram**), they zero in on the body heat of prey. Retractable, hypodermic-like fangs inject quick-killing venom that breaks down blood cells and body tissues. The rattle, shaken when the snake is startled, may have evolved as a warning to larger animals to watch their step.*



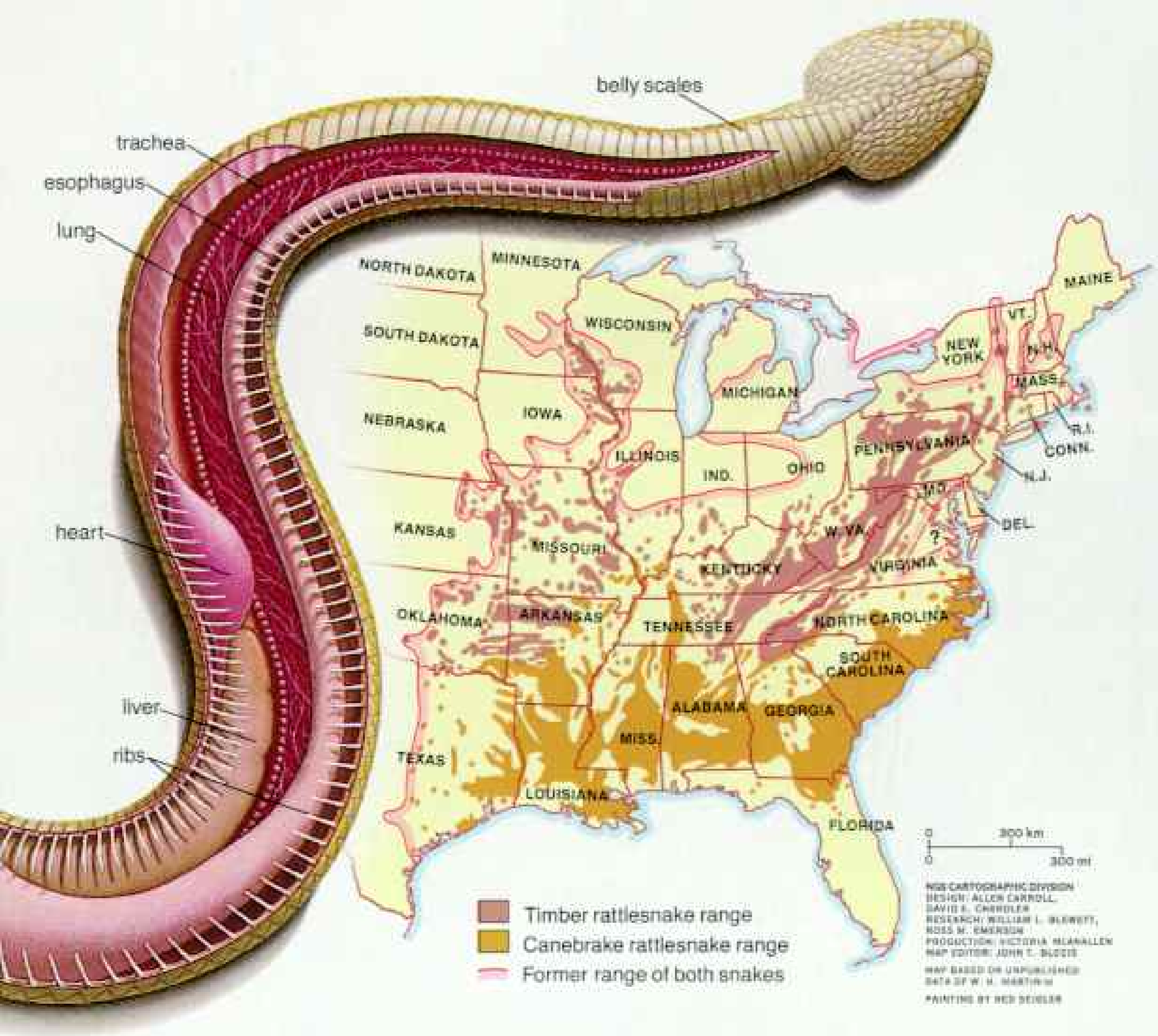
die naturally. Newly maturing younger females replace them, in a continuous population turnover.

Female timber rattlesnakes deliver their young alive, mostly in secure spots a quarter of a mile or more from the den, though some are born at the den itself. Each litter, averaging nine young, coils together, often intertwined in an amorphous pile.

By early October the young snakes have scattered. Most move back toward their home den; some don't make it, losing their way or succumbing to nighttime freezing. While the mechanism of their homing instinct hasn't been shown in nature, laboratory experiments suggest that baby snakes locate a den by tracking odor trails left by adult snakes.

Why don't dens become overcrowded? Populations of timber rattlesnakes, as of other wild creatures, tend to stay in balance. Predation reduces numbers: Raccoons, red-tailed hawks, eastern coyotes, black racer snakes, and—probably—bobcats and red foxes take a toll, mostly of young rattlesnakes. But freezing weather likely is the chief agent of attrition, as newborn snakes get caught out in the cold.

BY LATE MAY in an average year, most snakes have emerged and crawled away. With the arrival of hot days and warm evenings they gradually move farther and farther from their dens. These out-migrations, which I've tracked with small implanted radio transmitters,



take most of the population into forested uplands and ridges.

On reaching wooded areas away from the hibernaculum, some rattlers settle into sit-and-wait coiled postures, alert to ambush small mammals out foraging at twilight or after dark. I have caught hefty rattlers showing large bulges from recently eaten meals. Fur in fecal samples from the snakes shows that they feed mostly on white-footed mice and chipmunks, both abundant in the study areas.

Summer ranges for timber rattlers may be a mile or more distant from their dens. Through 1982 the farthest venturing rattler on my charts moved 1.7 miles from its winter base. So two miles seemed about the maximum migration outreach until the summer of 1984, when I found a road-killed snake 2.7 miles from its den and a live one 3.5 miles from home, a new record!

During the 1984 season I counted 14 rattlers killed on roads. Death on the highway seems to be a significant cause of mortality among timber rattlesnakes in states like New York, where they are legally protected from intentional harm.

As a venomous animal capable of causing death in a human, the rattlesnake has always aroused fear, particularly among those unfamiliar with its habits. Death at human hands has been the principal cause of the reptile's alarming decline in recent decades.

The fact is that the timber rattlesnake will almost always retreat from an encounter with man and, *(Continued on page 137)*

Nature's balance *of predator and prey is captured in a rare photograph of a black timber rattlesnake striking a white-footed mouse* ***(above)****. To document the behavior, the photographer kept the snakes in a home terrarium. This snake kills with one fang; a swollen sheath covers the broken right fang, an injury most commonly seen in captivity. Fangs are naturally replaced as many as four times a year.*

Loosely connected jaws spread as a yellow timber rattler begins to swallow a kill that may take four days to digest ***(far left)****. A final stretch reveals healthy fang sheaths* ***(left)****. In the wild the snakes eat only 6 to 20 meals a year.*

To study a snake more feared than understood, the author takes measurements in a laboratory at Skidmore College in Saratoga Springs, New York, while fellow herpetologist Randy Stechert gently restrains the snake against foam rubber with a plastic shield.

*Belly scales were clipped by Dr. Brown to encode a permanent identification pattern (**bottom right**). Rattles are color-coded (**middle right**) according to the location of each snake's den—natural crevices where they gather for winter hibernation. The pen points to a new rattle segment formed with the snake's shedding—once or twice a year.*

*Born in early September, not far from the mother's den, young first shed (**facing page**) within ten days. Abandoned by their mother a few days after birth, many perish from cold or predators such as raccoons and red-tailed hawks. Those that successfully locate a den probably follow an adult's scent trail. They return to one den throughout their lives. Implanted radio transmitters have helped determine that the snakes range an average of two miles from their den.*

if surprised, normally issues a warning with the characteristic *whir-r-r-r* of its vibrating tail. The snake rarely strikes humans except in self-defense. Almost anyone willing to set aside his snake aversion can accept rattlesnakes as marvelously suited predators, functioning in the natural environment as rodent controllers.

THE PRIMARY PURPOSE of venom-secreting glands and hypodermic-like fangs in poisonous snakes is to quickly kill the prey animal. For a human, a rattlesnake bite can be a serious medical injury. The venom, destructive of cells and tissues, threatens life through internal hemorrhaging, interference with blood clotting, cardiovascular shock, and kidney and respiratory failure. Fortunately, with modern hospital care and antivenin treatment, fatalities from rattlesnake bites are rare. Each year in the U. S. about 8,000 persons suffer bites from all venomous snakes; only 10 to 15 die.

I've had a couple of glancing strikes and suffered one serious bite. Two years ago a rattler landed me in the hospital. The hit came in self-defense. I was transferring a bagful of four big snakes from the trunk of my car to my backpack, preparatory to releasing them in the mountains. My hand brushed the bag, and a rattler struck through it. Only one fang connected, inflicting a slashing wound on my left hand at the base of the thumb.

An ambulance arrived in minutes. Within two hours my hand and arm ballooned almost to inner-tube size. The pain was excruciating. I required seven units of antivenin and spent four days in the hospital—then went right back to work, studying my "friends" and their rattles.

A newborn rattlesnake first sheds its skin in September at about ten days of age, and the first segment of the rattle, the button, is exposed. In June or July of the following year, when the snake again sheds, its second new rattle segment is produced next to the tail. With each skin shedding thereafter, the older segments move farther away from the tail, one at a time.

Few rattlesnakes carry an intact rattle, including the button, longer than ten segments. The largest I've seen on one of my marked snakes bore 20 segments, but it didn't taper to a narrow point and the button was missing. The snake was likely 22 or 23 years of age and quite possibly older.

An adult timber rattler's skin shedding takes place early each summer. No snake in my study has shed more often than twice a year, and about two-thirds shed only once.

RATTLES AND SKINS are often prized as keepsakes by those who kill timber rattlers. Once, while hiking on a logging road, I met a logger and a companion. We stopped for a chat, and the logger told me that he had killed several rattlers in the area. He pointed off to the side of the road. "They're in there," he said.

From the tangled brush I pulled out two large rattlesnake carcasses. "Did you notice the red paint on the rattles?" I asked. Yes, but he'd never seen a rattlesnake in the wild and thought red might be the natural color!

I carried the two snakes home. One was a large adult male I had marked more than six years earlier when he was a five-year-old weighing 422 grams. Now more than four feet long and weighing 1,028 grams (2.3 pounds), this strapping male had been struck down in his prime by the only real enemy he had. Such is probably the typical fate of most larger and older timber rattlers. Today very few survive to reach a length of four feet; the record is six feet two inches.

Although the timber rattlesnake has received little scientific attention, the snake

Power and grace *mark a timber rattler sipping from a terrarium pool. Adults average from three to four feet in length and have been known to live as long as 30 years in captivity. Among those studied by the author in the wild, the oldest was more than 20 years—it bore that many rattle segments, and some had broken off.*

may be thumbnailed as having a relatively long life expectancy, large adult size, late age of sexual maturity, low-frequency reproduction, and limited litter size. Juvenile survival rate is probably low, but once rattlers attain moderate to large body size, life for the most part becomes free of risk.

Rattlesnakes, however, like other long-lived animals such as whales, tortoises, bats, and condors, often are among the most vulnerable to unnatural agencies of mortality, notably humans. In New York State some populations have been totally extirpated; even the largest colonies have declined by half. In Pennsylvania too, despite tightened regulations, stocks have been reduced.

The main factors are unregulated "sport" hunting, commercial collecting for the live animal trade, market and bounty hunting, and campaigns of extermination. No wonder timber rattlesnakes in the Northeast are getting hard to find.

In June 1983 New York at last listed the timber rattler among its threatened species. This action gives the snake full protection under the state's Environmental Conservation Law; each violation can draw a penalty of $1,000.

New Jersey, Massachusetts, and, most recently, Connecticut line up with New York in protecting their remaining colonies. Vermont and New Hampshire, lacking protective regulations, find their few remaining colonies continuing to decline.

We are starting to learn about the complex and fascinating life history of the timber rattlesnake just when human pressures have nearly eliminated the chance to study it. Here is a species that clearly links us to untrammeled areas once so widespread across North America. To see one of these snakes coiled on the forest floor or lying peacefully on a remote mountain ledge is to gain a glimpse of a treasured but diminishing wilderness world. As a splendid exemplar of our natural heritage, the timber rattlesnake should be left undisturbed in its remaining habitats. □

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Key	Command
*	— Initiate Retrieval Commands

* FIRST

* BACKUP

* DELETE

* HELP

* LISTEN

* SAVE

* RESTART

* TRANSFER

* WAIT

* OPEN/EXIT

NEXT

AT&T Mail Talk Commands

Key	Command
1	— FIRST
2	— BACKUP
3	— DELETE/ RESTORE
4	— HELP
5	— LISTEN AGAIN
6	— SAVE
7	— STOP/START
8	— SPEED
9	— LAST
0	— EXIT
#	— NEXT TERM

Logon
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then press
Key in Pas
ID, then pr
key

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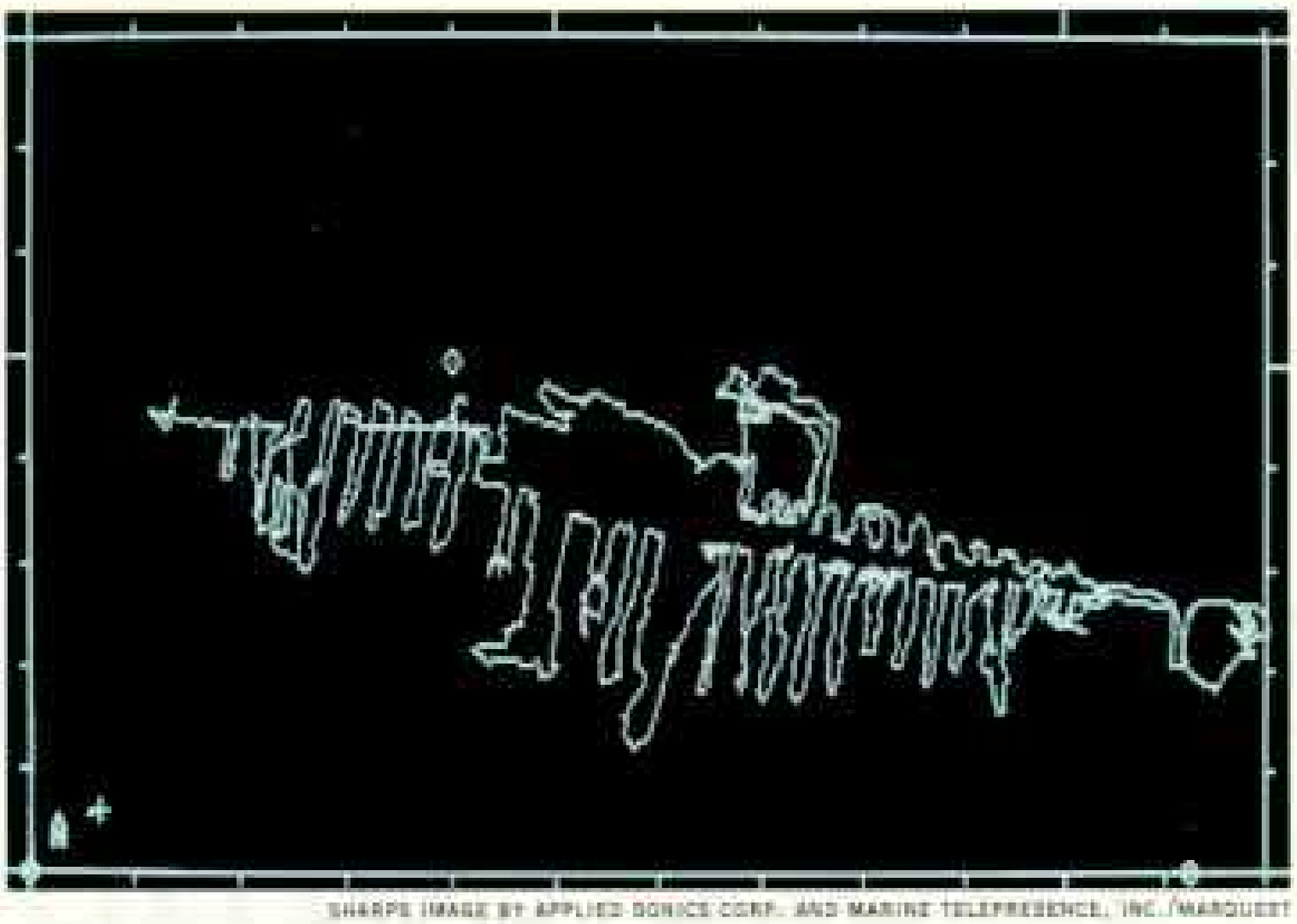
New undersea sensors probe old sunken ships

DEEP, DARK SECRETS may be just the thing in gothic fiction, but they are formidable barriers to underwater archaeology.

National Geographic photographer Emory Kristof and photo engineer Alvin Chandler have been working on the problems for years. Emory goes at a problem the way a drill goes at rock. He, Al, and their colleagues from many organizations make a widespread community of researchers, engineers, technicians, photographers, and others working together. For our part, I estimate that the Society contributes about $250,000 a year in basic development work, apart from specific research grants.

A recent advance is SHARPS (sonic high-accuracy ranging and positioning system). The skeletal image of an 1883 Chesapeake Bay oyster boat (**above**) was made by a diver

MARYLAND RESEARCH VESSEL LAUNCHES ROV SEA ROVER



SHARPS IMAGE BY APPLIED SONICS CORP. AND MARINE TELEPRESENCE, INC./MARQUEST

with what amounts to an electronic tracing gun, firing off 1,280 fixes—each accurate to within one inch—in less than an hour. These data points created the computer image, in effect positioning and measuring the wreck against an electronic grid. (To set a mechanical grid of pipes is slow and costly in clear water and all but impossible in black water.)

Emory estimates that SHARPS does the job a thousand times faster than could an unaided diver—and SHARPS is capable of tracing a wreck in three dimensions.

The other major problem is how do you get to a wreck? Divers' limits are quickly reached, and most manned submersibles are hugely expensive. Emory and his colleagues have been developing ever smaller and less expensive ROVs (remotely operated vehicles) that can do ever larger missions—notably a recent descent (**left**) to the 1870 wreck of the propeller steamer *New Jersey* in Chesapeake Bay.

Emory and such marine archaeologists as Donald Shomette of Maryland see a future of small, inexpensive ROVs guided by electronic consoles about the size and cost of a personal computer and about "as simple to operate as a color TV." This will be underwater exploration that scientists can afford, and that small companies can support technically.

I am pleased that the Society is helping in this work and freely passing along the technology we've helped to develop.

Gilbert M. Grosvenor

PRESIDENT, NATIONAL GEOGRAPHIC SOCIETY

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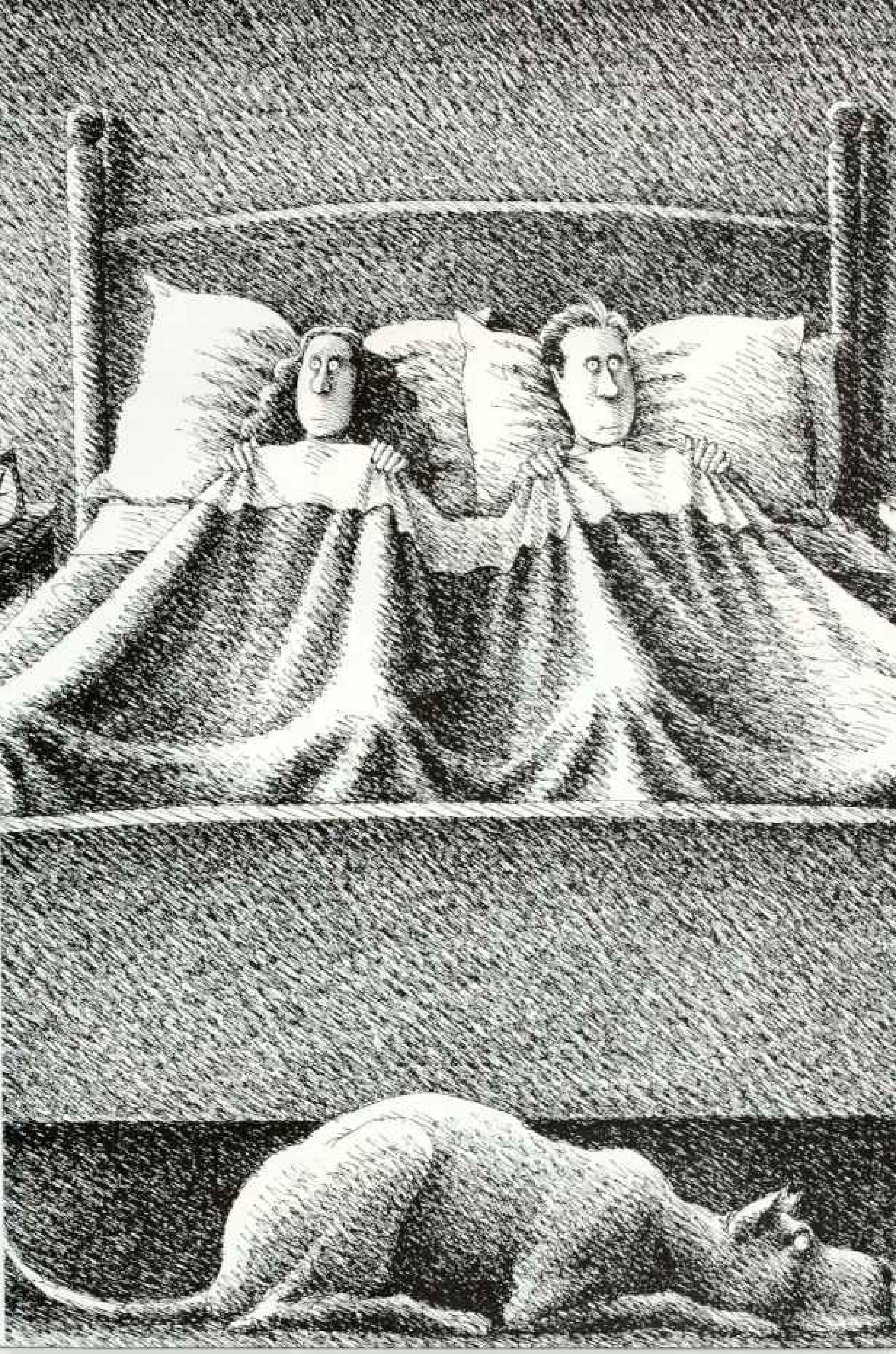

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Members Forum

North Dakota

I don't understand how you can title your article "Tough Times on the Prairie" (March 1987) when North Dakota farmers can get paid not to plant. In Louisiana, where unemployment is rampant, why can't fishermen get paid not to fish, or oil-field workers not to drill?

GERALD P. EIERMANN
Prairieville, Louisiana

It would be cheaper for the American taxpayer to close the state down, move everyone out, and abandon it back to nature. For a state that has a smaller population than most major cities, we sure are expending a large amount of tax money.

LEO G. SANCHEZ
New Orleans, Louisiana

The earliest explorers experienced tough times on the prairie and predicted the same for settlers. This was one of the last areas settled in the continental United States. As North Dakota grew, its expectations outstripped what the environment could ever consistently provide. Indians had long known the harshness and splendor of the prairie and lived accordingly.

JOHN G. SIDLE
Grand Island, Nebraska

The picture of Janice Herbranson talking to Jodi Sagvold is a fine example of a teacher exercising one of her most valuable attributes—listening.

JUDD H. BLACK
Rochester, New York

You mention, only in passing, the western half of the state. We do exist! We do have problems! And we do still have prairies.

CYNTHIA ZIMAN
Dickinson, North Dakota

The only reference to Grand Forks was to its air base. It is also home of the University of North Dakota. Incidentally, an article in the *Wall Street Journal* predicts Grand Forks will be fourth among "the nation's most affluent metropolitan areas at the beginning of the 1990s," based on Census Bureau, IRS, and state data. Southern Connecticut, Long Island, and Lake County, Illinois, rate first, second, and third.

CATHERINE TUTTLE SQUIRES
Nashua, New Hampshire

March Cover

Sincere thanks for your cover picture of a beautiful field of sunflowers being sprayed with poison, and the information inside that North Dakota farmers use herbicides now instead of cultivation. It turned us off sunflower oil. Why is poison still allowed on crops when there are biological methods? We already have *Bacillus thuringiensis* (BT) against gypsy moths and crop-destroying caterpillars, BTI against mosquitoes and gnats, insect growth regulators, and helpful lab-raised predators and parasites. More biological research and application should be of highest priority for human health, and the use of toxic materials banned. That would also help solve the toxic-waste problem and lessen the contamination of drinking water.

CAMPBELL NORSGAARD
Lakeville, Connecticut

Brazil

As a student of Brazilian history for 18 years, I read with interest the superb March article by Priit Vesilind and photographer Stephanie Maze. Brazil is on the brink, I believe, of being the world's next industrial leader, with the U. S. mainly a service-oriented society. But the comment that the "military is a dirty word now" should not be taken too seriously. The military was prominent even before the army took control of the political system. Military service is regarded by all classes to be honorable. Be certain, the army is waiting in the wings in case the civilian government flounders.

KENNETH H. LEEP, JR.
Stockton, California

Having been the iron-ore specialist at the Bureau of Mines for 15 years, I point out an error in the caption on page 372 that states that Brazil now leads the U.S.S.R. in iron-ore production. Brazil often leads in exports of iron ore, but its production is only about half that of the U.S.S.R., which is on the order of 240 million tons a year.

F. L. KLINGER
Bethesda, Maryland

Your poignant description of an eight-year-old living amid garbage won't leave me. Thank you for showing us the reality of this world, the squalor as well as the beauty. We can continue to improve the quality of our lives only if we help others gain prosperity, personal freedoms, and participation in government. Control of population growth seems to be crucial to Third World progress. How about an article on that subject?

PETER A. REINHARDT
Madison, Wisconsin

Regarding Pelé, how many readers would know that this is the nickname of Edson Arantes do Nascimento? In the past two decades, known

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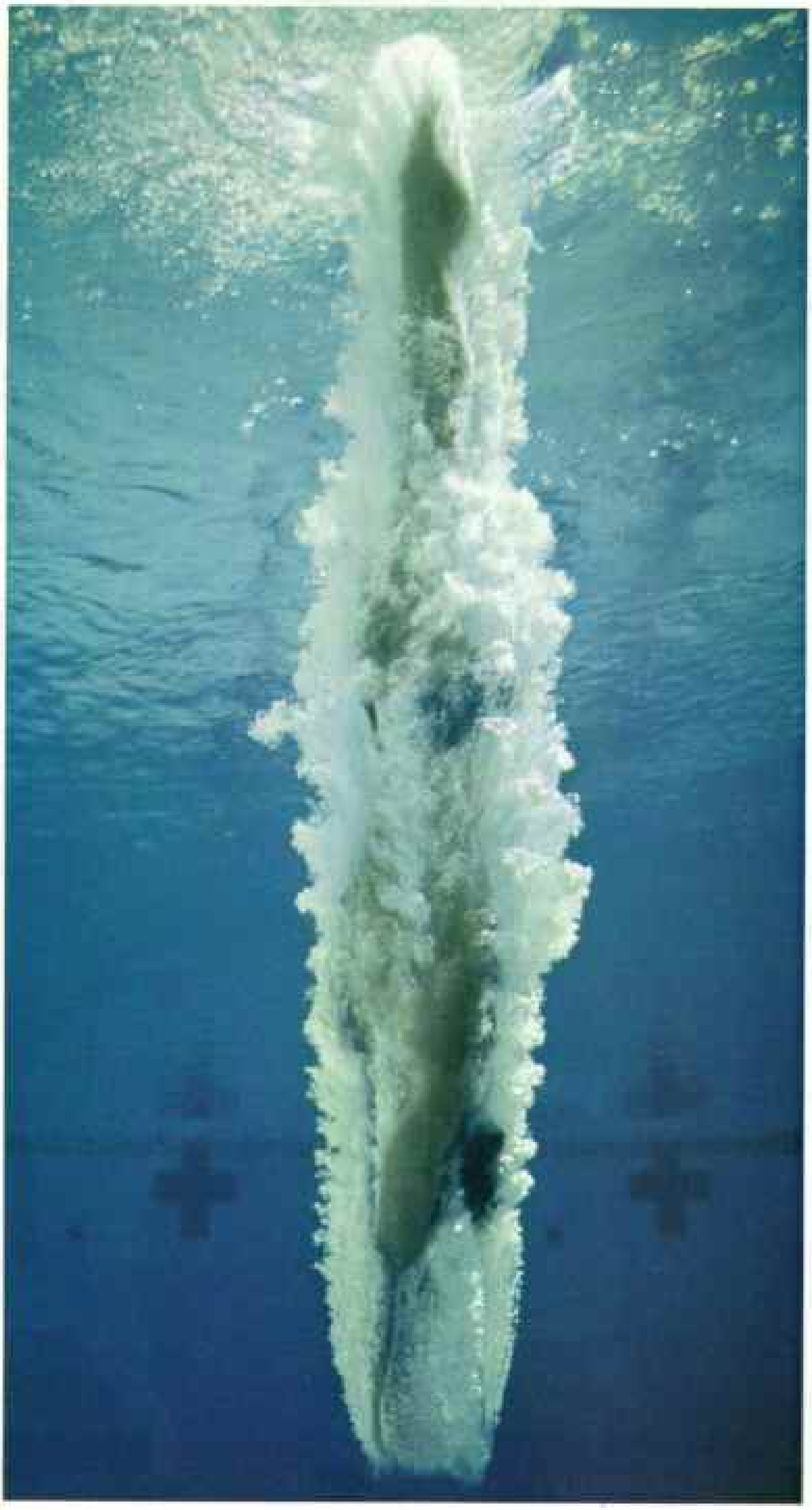

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as the world's greatest soccer player, he was a national hero in Brazil, where the populace is fanatical about *futebol*, which we call soccer.

HARRY W. CLIFFORD
East Orange, New Jersey

As an ecology-minded reader, I could take only despair from that well-written article on Brazil. Instead of pushing forward the reconstruction of the desolate cities and embracing a vigorous campaign for birth control, the government has chosen to spread the chaos to the remotest corners of the country by opening the rain forests for development. The outcome is easy to predict: misery on a still larger scale, many new *favelas*, and added stretches of exhausted land. All at the expense of the forest Indians.

DR. GERHARD RUSS
Leibnitz, Austria

The issue arrived the same week that Brazil announced it would not pay its national debt. With all the resources you tell of, I wonder why such a wealthy country is so poorly managed that it cannot meet its obligations.

MRS. FRANK H. PEASLEE
Fairfield, Iowa

It's been a long time since I've read such a downbeat piece. The good photographs enticed me. Brazil is more than the total of its parts. One

needs a little optimism to view such a grand subject. Brazil's greatest strength lies in her people's will, compassion, and optimism. From year to year I see vast changes for the better in Brazil. In future articles please emphasize some of them.

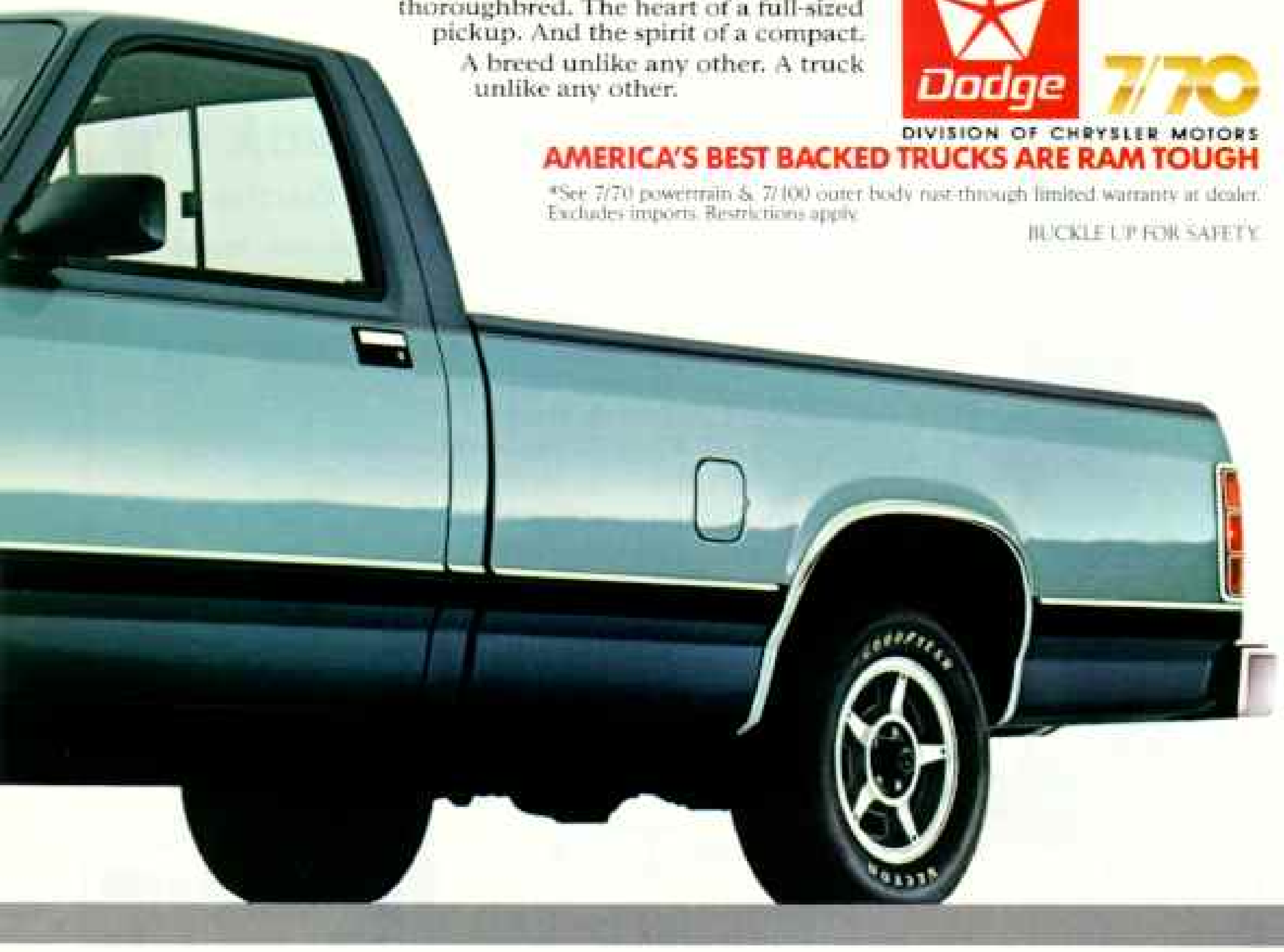
GEORGE F. JOHNSON
San Francisco, California

Mysteries of the Bog

Congratulations to Louise Levathes and photographer Fred Bavendam for their excellent article on peatlands (March 1987). Those strange lights reported in bogs at night, the will-o'-the-wisp or jack-o'-lantern, may not be so strange after all. Called fen fires in England and *Irrlichter* in Germany, they are well documented in older scientific literature. Peatlands generally are anaerobic and thus can reduce many chemicals. Where phosphorus is available, it can be reduced to phosphine, a volatile gas. Unstable in the presence of air, it spontaneously ignites, producing a green iridescent flame. Bog gases are also rich in methane and hydrogen, two flammable gases that may help fuel the fen fires.

WILLIAM SHOTYK
University of California
Riverside, California

The caption on page 401 states that scientists cannot figure out why the sedges grow in waves. I suspect they are indicative of the direction of



prevailing winds. The surface of the bog is fairly plastic and moves until it builds up enough weight to bind with the more stable layer below.

HARLO STANLEY
APO, New York

Those elongated hills (pages 400-401) are surely drumlins [hills of glacial drift], their long axis lying parallel to the flow of ice over northern Minnesota in the Pleistocene epoch. And classic drumlins at that.

DAVID WOOLSTON
Cascade, Colorado

Australia's Southern Seas

Comprehensive, well-written articles are "genetically" NATIONAL GEOGRAPHIC. We are never disappointed. Then in the March 1987 issue comes the epitome: "Australia's Southern Seas," by Richard Ellis. In rereading that beauty, I was virtually within stroking distance of the sea lions as well as those fascinating great whites.

LIZ COLE
Danville, Illinois

Little Big Horn

As a volunteer worker at the 1984 and 1985 archaeological surveys of the Custer battlefield, I found the article in December 1986 very interesting. However, the knife on page 801 does not have an aluminum handle. I am not a metallurgist, but I did have the good fortune to recover it.

MURRAY A. KLOBERDANZ
Osage, Iowa

We heard from many readers who pointed out that processing technology did not make aluminum inexpensive until after 1886. Subsequent laboratory analysis indicates the handle is a very thin tinned-iron stamping.

Members Forum

After reading the letters in March about the November 1986 article on MIAs, I am interested in learning more about the bracelets worn by several readers. I and many of my fellow cadets in ROTC units here at the University of Idaho would be honored to wear a bracelet in memory of an MIA.

ANNE M. WEIGLE
Moscow, Idaho

For information or a bracelet, write the Ohio Chapter, National League of Families of POWs and MIAs, Box 14853, Columbus, Ohio 43214.

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

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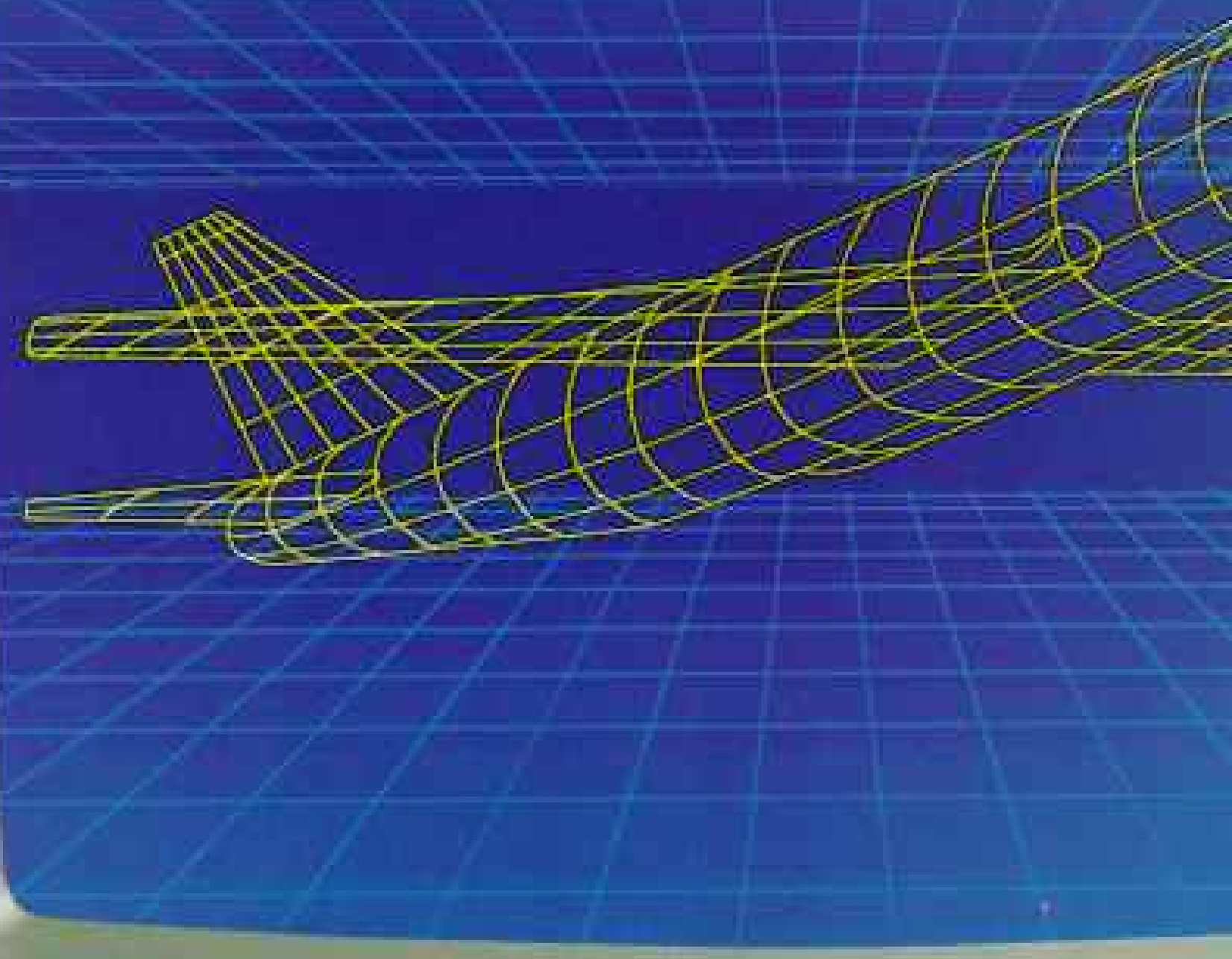

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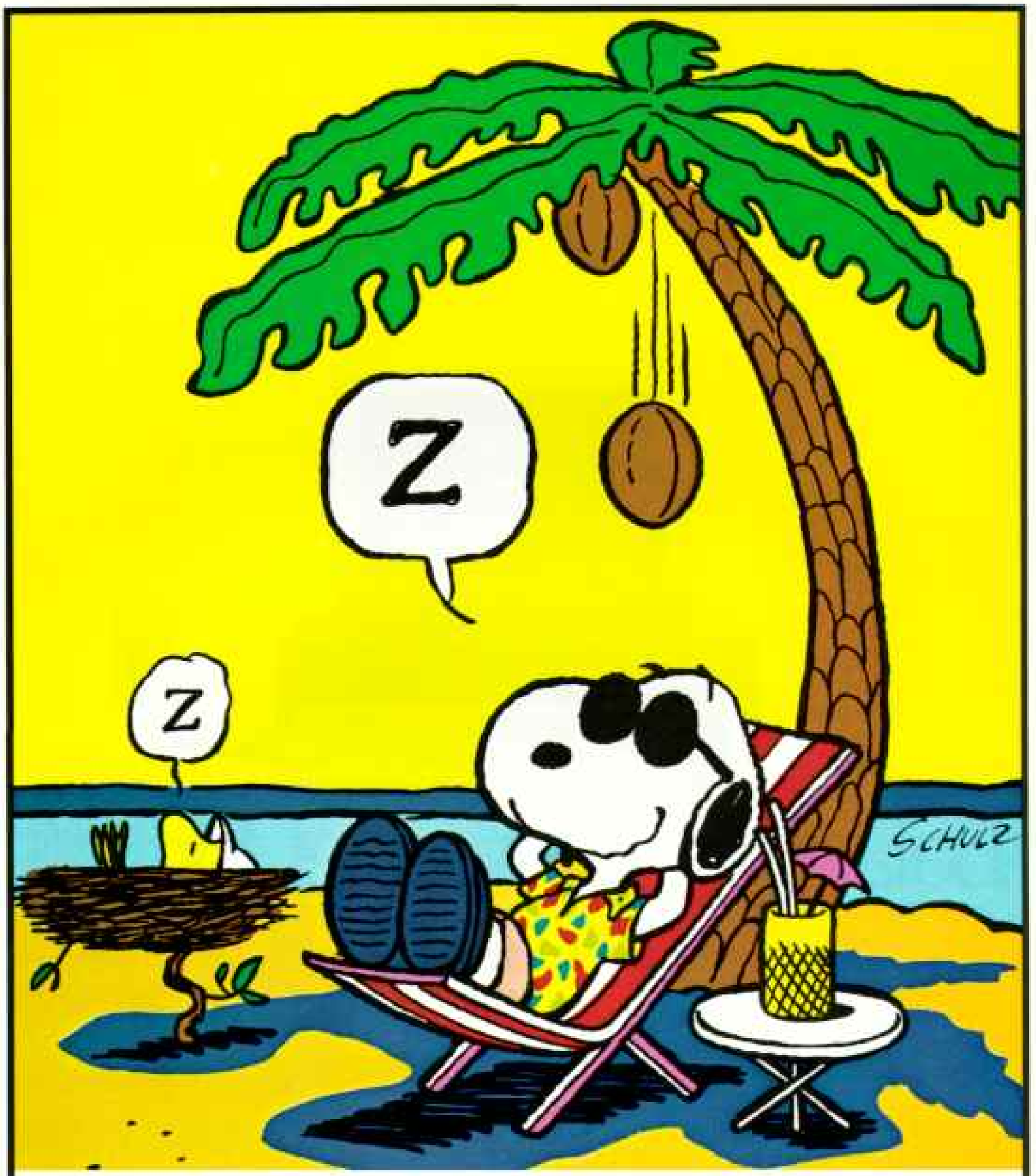

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GETTING CLOSE to his subject, staff writer ***Charles E. Cobb, Jr.,*** ponders Lake Erie near Ashtabula, Ohio, for his article on the Great Lakes in this issue. The Washington, D. C., native began his career in the 1960s, writing poetry about Mississippi cotton workers, and produced a TV film on recruiting pressures that face high-school basketball stars. Specializing in Africa as a free lance, Cobb reported on Zimbabwe for his first NATIONAL GEOGRAPHIC article in November 1981.

Typical of his approach, Cobb got close to Hurricane Gloria while covering the Outer Banks for a forthcoming issue. Holed up on North Carolina's Hatteras Island, he rode out winds that reached "only" 90 miles an hour. "I was lucky," he recalls. "It was a terrifying experience that I wouldn't want to repeat."

A Skidmore College associate professor, ***Dr. William S. Brown,*** now in his tenth year of timber rattlesnake tracking in New York (***below***), continues a vocation dating to his childhood on a Pennsylvania farm. His family tolerated his hobby well, he recalls, until "I marched into a dinner party and proudly displayed my pet queen snake and her 15 squirming babies."